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Journal of ECONOMIC ENTOMOLOGY

Published by the
ENTOMOLOGICAL SOCIETY OF AMERICA
Formed in 1953 by Consolidation of the
American Association of Economic Entomologists
(1889–1952)
and the former
Entomological Society of America (1906–1952)

VOLUME 48 December · 1955 NUMBER 6

JOURNAL OF ECONOMIC ENTOMOLOGY

Published by
ENTOMOLOGICAL SOCIETY OF AMERICA

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Washington 5, D.C.

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A bimonthly journal published on the 15th of February, April, June, August, October, and December, devoted to the interests of economic entomology. The authors are entirely responsible for statements in the *Journal*, whether of fact or opinion.

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Entered as second class matter at the Post Office at Menasha, Wisconsin. Acceptance for mailing at special rate of postage under the provisions of Sec. 34.40, Par. (D), provided for in the Act of February 28, 1925, embodied in paragraph 4, Section 538, P. L. and R., authorized May 1, 1936.

PRINTED BY THE GEORGE BANTA CO., INC.
MENASHA, WISCONSIN, U.S.A.

Issued JANUARY 23, 1956

JOURNAL OF ECONOMIC ENTOMOLOGY
ENTOMOLOGICAL SOCIETY OF AMERICA
Formerly Official Organ American Association of Economic Entomologists

Vol. 48 December, 1955 No. 6

Control of Peach Catfacing Insects in Illinois[1]

S. C. CHANDLER[2]

The studies of 1953 and 1954 are reported in this article but since they are the outgrowth and sequence of earlier work, the previous investigations in Illinois are first briefly summarized.

PREVIOUS STUDIES.—The first experimental work on the control of catfacing insects was done during the years of 1925, 1926, and 1927. Studies were made simultaneously at Carbondale, Illinois, and Vincennes, Indiana, primarily to determine the causes of the injury. During this period it was established that the plum curculio, *Conotrachelus nenuphar* (Hbst.), the tarnished plant bug, *Lygus lineolaris* (P. de B.), and several stink bugs were responsible for most of the injury. Unsatisfactory control was obtained at that time with the insecticides available. Materials used in cage and orchard tests were dusts of calcium cyanide, sulphur cyanide, sulphur naphthalene and nicotine, and sprays of nicotine sulfate. This work was published by Porter *et al.* (1928).

The next period of study, from 1943 to 1946 inclusive, followed the advent of DDT. It was determined that two applications of this material, one when about 50% of the blossoms were open and the other when shucks were splitting, gave 50 to 80 per cent control of catfacing, and that the same degree of control could be obtained by directing the sprays or dusts on legumes grown in the orchard. These studies were reported by Chandler (1943, 1944, 1945, 1946, 1947, 1948). During this period the effect of plum curculio on catfacing was shown.

Following the introduction of BHC and chlordane into our peach spray and dust schedules, studies were resumed in 1948. It was found that either of these materials could be substituted for DDT with about equal results.

In 1951, 1% parathion dust was reported by Chandler (1952) to be as effective as 5% DDT dust.

Severity of the injury was determined by annual peach harvest surveys which include records from 1942 to date. According to these surveys, the average percentage of fruit injured by catfacing in 30 or more typical orchards has been as follows:

1942	11.7
1943	19.9
1944	3.8
1945	5.8
1946	12.2
1947	4.8
1948	10.7
1949	9.6
1950	8.6
1951	4.15
1952	6.5
1953	3.26
1954	2.63

Catfacing injury usually equalled or exceeded all other insect-caused injuries to peaches recorded in the annual surveys, as reported by Chandler (1953). For this reason it was decided in 1953 to repeat some of the earlier work and test the three most promising insecticides, DDT, dieldrin, and parathion, at different stages in the development of the peach in cages and in the orchard.

CAGE TESTS.—Cage tests designed to determine tarnished plant bug and stink bug control attained and residual effectiveness of materials tested were in general unsuccessful. Because of the many variables encountered the results obtained were not significant. However, in summarizing results of the 103 separate tests conducted in 1953 and 1954 it would appear that:

(1) DDT, dieldrin, and parathion at normal dosages used in orchard sprays will kill when sprayed on the insects or when insects are caged on sprayed foliage.

(2) The three insecticides were about equally effective. Dieldrin was effective over the longest period of time, followed by DDT. Parathion was very effective for the first few hours, but was very short lived.

(3) All insecticides were less effective on stink bugs than on lygus bugs. Except for a short period after application when parathion was most efficient, dieldrin was superior to the other two materials.

ORCHARD TESTS.—Tests were conducted in 16 orchards in 1953 and in 10 in 1954. In 13 of the 16 orchards in 1953 and in all 10 in 1954 the primary objective was to study timing of applications of the same three insecticides used in the cage tests, dieldrin, DDT, and parathion. In the other three orchards in 1953 the three insecticides were compared when all were applied at the same time. Only the standard strengths of materials were used; in spray form the amounts of actual materials per 100 gallons were: dieldrin, $\frac{1}{4}$ pound; DDT, 1 pound; and parathion, 3/10 pound. As dusts, dieldrin was used at $2\frac{1}{2}$%, DDT at 5%, and parathion at 1%. Plots were all large, containing from 100 to 200 trees. Experiments were all conducted by growers, under supervision. In each of the 23 timing tests the cooperator was asked to spray or dust two main blocks, using one of the three insecticides, starting one

[1] Accepted for publication March 21, 1955.
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block in a certain stage in peach development and the other one stage later. Both blocks received the insecticide decided upon at each application until shucks were all off the peach or later, at the wish of the cooperator, usually three or four times in all, after which the grower changed to any schedule he wished as long as both blocks received the same treatment. The block started first would of necessity receive one more application of the test material than the one started later. In some cases the grower left a partial check with no insecticides whatever until shucks were all off. In a number of cases duplicate sets of blocks were used by the grower, either with the same material or with another in comparison.

To determine when final infestation records could be made so as to include most of the typical catfacing, examinations were made at three successive periods. Preliminary records made when shucks were just off the fruit showed appreciably less injury than when made later. On the other hand, examinations of 32,000 peaches in 64 blocks made about 3 weeks after all shucks were off showed no more catfacing than was found in the same number of peaches in the same blocks about 6 weeks later and it was concluded that nothing was gained by waiting until the later time.

The method finally adopted in making infestation records was to examine 25 peaches at random from each of 40 trees in each plot, making a total of 1000 per plot. By this method some fruit was examined on from 20 to 40 per cent of the trees in the block.

Data from the 13 orchards studied seemed to indicate that in 1953 there was some advantage in starting applications in the pink stage as compared with the blooming period, and in the bloom as compared with the petal fall stage with a possibility of two bloom applications being better than one. The contrast between early and late starting of treatments was greater with dieldrin than with parathion, indicating that the dieldrin deposit remained effective longer.

In three of the orchards studied in 1953, dieldrin, DDT and parathion were used in the early applications for catfacing insects, using the same timing for all three materials. Dosages used were those noted above. Table 1 shows the spray and dust schedules followed.

Subsequent applications using the same insecticides in all three blocks, were left to the grower to make as he saw fit. Actual schedules used were as follows:

Orchard No. 1—5/15, 5/25, 6/15, 7/1 Chlordane-DDT spray
Orchard No. 2—5/18, Dieldrin-DDT spray
—5/28, 6/11, 6/18, Chlordane-DDT spray
7/11, Parathion spray
Orchard No. 3—5/8, 5/16, 5/23, 5/30, 6/16, 6/6, 6/13, 6/20, 6/27, 7/6, 7/20, 8/3, Parathion dust.

Final infestation in these three orchards averaged 35.7 catfaced peaches per 1000 in the dieldrin blocks, 32.7 in the DDT and 45.0 in the parathion. The differences between dieldrin and DDT are not significant, but there is an indication that both are superior to parathion in reduction of the injury.

In 1954 field tests were conducted in 10 orchards. Since dieldrin had proved in other investigations to be superior to any other insecticide for the control of the plum curculio and the best control had been secured by starting applications early, major emphasis was laid on this material for control of other catfacing insects. However, since parathion is widely used in Illinois peach spray and dust schedules, it was also included in orchard tests. Less emphasis was placed on DDT, as it is of little value for control of the plum curculio. The same method of grower cooperation was used as in 1953.

In the first group, one block in each orchard was first sprayed or dusted in the pink stage, and in another no poison was applied until the bloom stage. From the bloom stage on, both blocks received the same schedule. In the second group, no pink-stage application was made, but at early bloom one block in each orchard was treated and nothing applied to the other until late bloom when both were treated. In the third group no applications were made until late bloom in one block and petal fall in the second.

A summary of final infestation records is shown in table 2. It will be seen that with the exception of the Boyd orchard, where DDT was used, the earlier-treated blocks invariably showed less catfacing than those treated later. Since this shows that insecticides were applied as early as the pink and early bloom stages, when jarring records indicated very few insects of any kind present that produce peach catfacing, the effect of the insecticides must carry over to later stages. Hence, the value of a long lasting poison is seen. Comparisons between dieldrin and parathion in table 2 should be made only in the Hartline

Table 1.—Spray and dust schedules followed in three orchards in early season, 1953, using three insecticides in separate blocks, using the same timing.

Orchard No.	Dates	Stage	Insecticides Used in		
			Dieldrin Block	DDT Block	Parathion Block
1	3/23	Early bloom	Dieldrin spray	DDT spray	Parathion spray
	4/21	Shuck-split	Dieldrin spray	DDT spray	Parathion spray
	5/1	Shuck-off	Dieldrin spray	DDT spray	Parathion spray
2	4/7	Petal fall	DDT-BHC dust	DDT-BHC dust	DDT-BHC dust
	4/28	Shuck-split	Dieldrin spray	DDT spray	Parathion spray
	5/9	Shucks off	Dieldrin spray	DDT spray	Parathion spray
3	3/23	Full bloom	Dieldrin dust	DDT dust	Parathion dust
	4/23	Shuck split	Dieldrin dust	DDT dust	Parathion dust
	5/1	Shucks three-fourths off	Dieldrin dust	DDT dust	Parathion dust

Table 2.—Insecticide tests for control of peach catfacing in 1954, in which the first application was made at varying stages in the development of the fruit.[a]

Orchard	Insecticides	Applications First	Applications Total	Number Catfaced	Applications First	Applications Total	Number Catfaced	Applications First	Applications Total	Number Catfaced
Bilbury	Dieldrin spray	Pink stage	5	31	Bloom	4	56	Shuck off	3	79
	Dieldrin with DDT	Pink stage	5	39						
Hartley	Dieldrin spray									
	Prairie variety	Pink stage	4	16	Bloom	3	58			
	Gage Elberta	Pink stage	4	16	Bloom	3	28			
Arnold[b]	Parathion spray	Pink stage	5	27	Bloom	4	36	Shuck off	2	260
Boyd[c]	DDT spray	Pink stage	4	15	Bloom	3	13			
Clark Brower	Dieldrin spray	Early bloom	5	28	Late bloom	4	106	Shuck off	2	191
	DDT dust, then dieldrin[d]	Early bloom	5	46						
Floyd[e]	Dieldrin spray	Early bloom	6	59	Late bloom	5	76	Shuck off	4	62
Beauman	Dieldrin spray	Early bloom	5	19	Late bloom	4	26	Shuck off	3	50
Hartline	Dieldrin dust[f]	Early bloom	4	14	Late bloom	3	28	Shuck off	1	46
	Parathion dust	Early bloom	4	32	Late bloom	3	61	Shuck off	1	43
Flamm	*North Orchard*									
	Dieldrin dust	Early bloom	5	16	Late bloom	4	26			
	Parathion dust	Early bloom	5	22	Late bloom	4	40			
	South Orchard									
	Dieldrin dust	Early bloom	5	13	Late bloom	4	20	Shuck off	0	62
	Parathion dust	Early bloom	5	15	Late bloom	4	26			
Sauer[g]	*North Orchard*									
	Dieldrin spray	Late bloom	2	11	Petal fall	1	27			
	South Orchard									
	Dieldrin spray	Late bloom	2	15	Petal fall	1	19			

[a] Number of catfaced peaches in 1000 fruits recorded in each orchard except as noted.
[b] Calculated from 700 peaches examined in each of treated blocks and 100 in check block.
[c] DDT in pink and late bloom stages, parathion sprays starting when shucks one-half off.
[d] Grower schedule, DDT dust in early and late bloom, DDT with dieldrin spray in petal fall, shuck split followed by four more dieldrin sprays.
[e] Small check block close to large block sprayed in early bloom.
[f] Check block in parathion dust test, narrow and subject to drift from dieldrin dust block.
[g] Applied with liquid duster, as concentrate dieldrin in the liquid.

and Flamm orchards where they were used side by side. Dieldrin dust was significantly better than parathion dust in these tests.

There has been some concern over the effect of insecticides on bees when applied during the blooming period. The use of DDT in one application during the bloom of peach has been an established practice in Illinois since 1946, and has been recommended by the Illinois Experiment Station since 1948. Three considerations have brought this about: First, little or no reduction in size of bee colonies has been noted from the practice; second, peaches bloom earlier than apples during a period when cool, windy, showery weather is the rule and when a small percentage of the bees in a hive are flying; and third, the tarnished plant bug, responsible for part of the catfacing, is attracted to the bloom, and is found in only small numbers after petals have fallen.

The effect of dieldrin on bees is of greater importance than is either DDT or parathion. This is because, of the three insecticides, only dieldrin and parathion are effective against both the plum curculio and the sucking insects causing most of the catfacing, and of these two insecticides dieldrin is superior. In 1951 the late Carl J. Weinman took hives of bees into southern Illinois peach orchards, some sprayed with dieldrin in the blooming period and some with no bloom sprays. He could not detect any difference in the strength of colonies at the end of the blooming period.

SUMMARY.—Studies of peach catfacing during the years 1925–1927 resulted in poor control with the insecticides then available. At later periods, 1943–1946, 1948, and 1951, information was secured on control of catfacing insects with DDT, BHC, chlordane, and parathion. Rechecking some earlier work and entering into new phases of the problem, the studies of 1953 and 1954 brought out the following:

Cage tests showed that tarnished plant bugs and stink bugs can be killed by dieldrin, DDT, or parathion,

either by spraying the insects or by the insects coming in contact with sprayed foliage and fruit. The persistence of the insecticides was in the order named.

Large scale orchard tests showed the value of early applications of dieldrin, DDT, and parathion. Applications started in the pink stage were more effective than those started in the bloom stage; applications started in early bloom were more effective than those started in late bloom; and applications started in late bloom were more effective than those started in the petal fall stage. Of the two insecticides, dieldrin and parathion, which will control both plum curculio and the sucking insects, dieldrin is the better both as a spray and as a dust.

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Diaryl-trifluoromethyl-carbinols as Synergists for DDT Against DDT-resistant House Flies[1]

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The problem of insect resistance to DDT is acute in Israel, especially with regard to house flies which in many localities can not be controlled any more with DDT. This study was undertaken to find synergists for DDT which would render it again active against DDT-resistant insects.

Synergists which potentiate DDT have recently been reviewed by Summerford (1954). Amongst the many materials which have been tested the most active ones are compounds structurally related to DDT (Summerford *et al.* 1951; March *et al.* 1952; Speroni *et al.* 1953). As it is particularly striking that a carbinol Bis-(p-chlorophenyl) methyl-carbinol (DMC) is of outstanding activity, it seemed surprising that other carbinols have not been extensively tested so far. An attempt to synthesize *p,p'*-disubstituted diaryl-trichloromethyl-carbinols having failed (Kaluszyner & Reuter 1953), a series of the corresponding diaryl-tri*fluoro*methyl-carbinols were synthesized in these laboratories (Kaluszyner *et al.* 1955) and tested for synergistic activity with DDT.

MATERIALS AND METHODS.—The house fly species used in these experiments was *Musca vicina* Macq. The flies were collected in the field in 1951 and have since been reared in the laboratory without exposure to any insecticide. This strain is designated as "Tel Hashomer" strain (T). The degree of resistance to DDT of this strain is unknown, since no susceptible laboratory strain of *M. vicina* was available for comparison. However, comparisons of insecticidal tests carried out by the author on a susceptible strain of *Musca domestica* L. at the University of California, Berkeley (Tahori & Hoskins 1953) with the "T" strain, indicated that the latter was about 15 times as resistant to DDT as the "Berkeley" strain.

A DDT-resistant strain of *M. vicina* was collected at Eilat near the Gulf of Aqaba during June 1953. At this time, it was three times more resistant to DDT than the "T" strain. By selection in the laboratory for nine generations, this strain became 14 times more resistant to DDT than the "T" strain. It will be designated further as "R" strain. *p,p'*-DDT, recrystallized twice from ethanol, m.p. 108.5° C., was used in all comparative tests. Benzene solutions of the chemicals were applied topically to the ventral thorax of individual flies by means of a microloop. The microloop delivered a constant volume of 0.3 mm.[3]

Twenty-five female flies, 3 to 4 days old, were used in each test, and at least two experiments were carried out with each concentration. Following exposure, the flies were held in glass jars at 26° C. and 60 to 70% relative humidity and were provided with food and water. Mortality counts were taken after 24 hours.

In another series of tests, residual effectiveness was determined by impregnating discs of filter paper with acetone solutions of the chemicals. In each case 1 ml. solution of DDT, alone or in combination with the potential synergist, was pipetted uniformly on the filter paper and the latter placed in a petri dish 15 cm. in diameter. One set of residues was aged at room temperature and another set at 37° C. and 60 to 70% relative humidity. At different time intervals after treatment, 25 flies were introduced into each petri dish and kept for 1 hour. After exposure, the flies were transferred to clean

[1] Accepted for publication April 3, 1955.

Table 1.—**Insecticidal and synergistic activities of materials as compared to DDT, against "Tel Hashomer" strain of *Musca vicina*.**

Compound	Insecticidal Activity Compared to DDT	Synergistic Activity DDT/Synergist 1:1	Synergistic Activity DDT/Synergist 10:1
1. DDT	1	1	1
Carbinols			
2. Bis-(p-chlorophenyl)-trifluoro-methyl-carbinol	1/3	25	15
3. Bis-(p-fluorophenyl)-trifluoro-methyl-carbinol	1/4	16	10
4. Bis-(p-bromophenyl)-trifluoro-methyl-carbinol	1/5	16	12
5. Bis-(p-methoxyphenyl)-trifluoro-methyl-carbinol	1/6	12	5
6. Bis-(p-nitrophenyl)-trifluoro-methyl-carbinol	1/8	10	4
7. Bis-(p-ethoxyphenyl)-trifluoro-methyl-carbinol	0	4	0
8. Bis-(p-tolyl)-trifluoromethyl-carbinol	0	4	0
9. Diphenyl-trifluoromethyl-carbinol	0	2	0
10. Bis-(p-chlorophenyl)-pentafluoropropyl-carbinol	0	0	0
11. Bis-(p-chlorophenyl)-heptafluorobutyl-carbinol	0	0	0
12. p-Chlorophenyl-trifluoromethyl-carbinol	0	0	0
13. p-Chlorophenyl-trichloromethyl-carbinol	0	0	0
Ethanes			
14. 1,1-Diphenyl-2,2,2-trifluoroethane	0	0	0
15. 1,1-Di-(p-methoxyphenyl)-2,2,2-trifluoroethane	0	2	0
16. 1,1-Di-(p-tolyl)-2,2,2-trifluoroethane	0	0	0
17. 1,1-Di-(chlorophenyl)-2,2,2-trifluoroethane	1/3	14	0
18. 1,1-Di-(p-bromophenyl)-2,2,2-trifluoroethane	1/3	10	0
19. 1,1-Di-(p-chlorophenyl)-1-chloro-2,2,2-trifluoroethane	0	3	0
20. 1,-Di-(p-nitrophenyl)-2,2,2-trichloroethane	1/10	2	0
21. 1,Di-(p-chlorophenyl)-1, chloro-2,2,2-trichloroethane	0	0	0
Esters			
22. Diphenyl-trifluoromethyl-carbinyl acetate	1/7	2	0
23. Diphenyl-trifluoromethyl-carbinyl propionate	0	0	0
24. Bis-(p-nitrophenyl)-trifluoromethyl carbinyl acetate	0	0	0
25. Bis-(p-chlorophenyl)-trifluoromethyl-carbinyl acetate	1/4	15	11
26. Bis-(p-bromophenyl)-trifluoromethyl-carbinyl acetate[a]	1/2	14	10
27. Bis-(p-tolyl)-trifluoromethyl-carbinyl acetate	0	0	0
Miscellaneous			
28. 1,1-Bis-(p-nitrophenyl)-2,2-dichloro ethylene	1/16	0	0
29. β,β-Diphenylpropionic acid	0	0	0
30. 4,4′-Dichlorobenzilic acid	0	0	0

[a] This compound is very slow acting; mortalities 24 and 48 hours after topical application are negligible, but rise on 3rd and 4th day.

glass jars and treated as described above. The same residue was used throughout the duration of the experiment with any given concentration.

RESULTS.—The insecticidal effectiveness of each compound and its synergistic activity with DDT are summarized in table 1. Synergistic activity is defined as the factor by which it is possible to reduce the amount of DDT and still obtain the same mortality; for example, when bis-(p-chlorophenyl)-trifluoromethyl-carbinol was added to DDT at a ratio of 1:10 the amount of DDT necessary to give a mortality of 50% could be reduced from 3.0 microgram/fly to 0.2 μg.

Of the various compounds tested, bis-(p-chlorophenyl)-trifluoromethyl-carbinol was found to be the most effective synergist. It will also be noted that when used alone, this compound was slightly more toxic for the "T" strain of *M. vicina* than all other compounds. This observation is in keeping with the general correlation existing between insecticidal and synergistic activity.

Table 2 shows a comparison of the relative synergistic activities of bis-(p-chlorophenyl)-trifluoromethyl-carbinol and three previously reported DDT-synergists, viz, bis-(p-chlorophenyl)-chloromethane, bis-(p-chlorophenyl)-ethane and bis-(p-chlorophenyl)-methyl-carbinol (March *et al.* 1952). The trifluoromethyl-carbinol was the most active synergist against the "T" and the "R" strains.

Results of the residual effectiveness of DDT alone and of DDT in combination with bis-(p-chlorophenyl)-trifluoromethyl-carbinol are shown in table 3. DDT alone, at 40 mg. per petri dish (equivalent to 200 mg./sq. ft.) was fairly toxic after 3 days but lost its effectiveness after 7 days. A combination of 40 mg. DDT and 4 mg. of the synergist proved highly effective after 55 days, producing 92 per cent mortality. When compared in a residual test with the three DDT-synergists mentioned above (Table 4) the trifluoromethyl-carbinol proved to be the most effective.

DISCUSSION.—Table 1 shows that of the compounds tested, the carbinols were always more effective synergists than the corresponding hydrogen compounds, (compare compounds 2 and 17; 4 and 18; 5 and 15; 6 and 20; 8 and 16; and 9 and 14) or the corresponding esters (2 and 25; 4 and 26; 6 and 24; 8 and 27). Chlorine in the *para* position gave the highest synergistic effect, followed in decreasing order of activity by bromine, fluorine, methoxy, nitro, methyl and ethoxy. Replacement of these substituents by

Table 2.—Dosage-mortality relationships for DDT alone and in combination with each or four synergists against the "T" and "R" strains of *Musca vicina*.[a]

Microgram/Fly		"T" Strain		"R" Strain	
DDT	Synergist	Per Cent Mortality	Relative Synergistic Activity[b]	Per Cent Mortality	Relative Synergistic Activity[b]
1.5		10			
2.0		20			
3.0		52	1		
5.0		80			
10.0		100			
15.0				10	
30.0				34	1
50.0				60	
100.0				88	
	Bis-(p-chlorophenyl)-trifluoromethyl-carbinol				
0.15	0.015	32			
0.20	0.02	48		15	
0.30	0.03	80	15	45	127
0.50	0.05	96		70	
1.00	0.10			92	
7.00		28			
10.00		60			
15.00		92			
	Bis-(p-chlorophenyl)-chloromethane				
0.15	0.015	10			
0.20	0.020	20		10	
0.30	0.030	52	10	32	93
0.50	0.050	84		56	
1.00	0.100			88	
30.00		30			
40.00		60			
50.00		84			
	Bis-(p-chlorophenyl)-ethane				
0.2	0.02	12		8	
0.3	0.03	32	7.5	20	70
0.5	0.05	64		44	
1.0	0.10	96		76	
15.0		20			
20.0		50			
30.0		85			
	Bis-(p-chlorophenyl)-methyl-carbinol				
0.2	0.02	8			
0.3	0.03	20		10	
0.5	0.05	50	6	25	46
1.0	0.10	88		55	
2.0	0.20			85	
20.0		15			
30.0		50			
50.0		90			

[a] Average of five tests.
[b] Activity of DDT alone = 1.

Table 3.—Mortalities of "T" flies exposed for 1 hour to residual deposits of DDT and Bis-(p-chlorophenyl)-trifluoromethyl-carbinol.[a]

	24-Hour Mortalities (Per Cent)					
	Age of Residue (Days)					
Toxicant	1	3	7	12	25	55
20 mg. DDT	0	68	0	16	8	0
40 mg. DDT	20	85	20	8	28	20
20 mg. DDT+2 mg. synergist	30	100	92	92	92	24
30 mg. DDT+3 mg. synergist	56	100	100	100	100	88
40 mg. DDT+4 mg. synergist	56	100	100	96	100	92
Control	0	4	0	8	0	0

[a] Petri dishes kept at 37° C.

hydrogen reduced the activity to almost nil. A prolongation of the aliphatic chain or elimination of one phenyl group destroyed the synergistic activity completely (compare compound 2 with compounds 10, 11, and 12).

It will be noted that with regard to the carbinols there exists a relationship between synergistic activity and the ratio: DDT to synergist. When this ratio was 1:1, the synergistic activity was approximately 60% higher than for the 10:1 ratio; however, no such relationship exists with the corresponding ethanes. None of the ethanes showed any synergistic activity at the 10:1 ratio, although some of them were quite active at the ratio of 1:1.

Table 4.—Mortalities of "T" flies exposed for 1 hour to residual deposits of DDT and various synergists at 20° and 37° C.

Toxicant	Temperature in ° C.	24-Hour Mortalities (Per Cent) Age of Residue (Days) 1	2	3	5	7	14	21	45
5 mg. DDT	20	24	14	20	12	0	0	0	0
5 mg. DDT	37	0	16	4	16	8	0	0	0
100 mg. DDT	20	60	52	60	52	24	20	28	24
100 mg. DDT	37	100	100	100	100	84	100	100	100
5 mg. DDT+0.5 mg. Bis-(p-chlorophenyl)-trifluoromethyl-carbinol	20	100	80	68	24	12	24	20	40
	37	100	100	42	16	0	0	0	0
5 mg. DDT+0.5 mg. Bis-(p-chlorophenyl)-chloromethane	20	60	0	20	12	0	0	0	0
	37	100	24	16	12	4	0	0	0
5 mg. DDT+0.5 mg. Bis-(p-chlorophenyl)-ethane	20	92	84	18	28	0	0	0	0
	37	100	24	28	8	8	0	0	0
5 mg. DDT+0.5 mg. DMC	20	40	20	60	32	12	0	0	0
5 mg. DDT+0.5 mg. DMC	37	16	4	4	8	4	0	0	0
Control	20	0	4	0	0	0	0	0	0
Control	37	4	0	0	8	0	4	0	0

Though Kirkwood *et al.* (1946) state that 1,1-di-(p-chlorophenyl)-2,2,2-trifluoro-ethane possesses only a very low insecticidal activity, viz, 1/100 that of DDT against *Drosophila melanogaster* this compound was found to be about one-third as toxic as DDT against the house fly. It should be noted that the compound tested, as prepared by Kaluszyner *et al.* (1955) by an independent method, had a melting point (46° C.) different from that indicated by Kirkwood *et al.* (1946).

It was interesting to see if bis-(p-chlorophenyl)-trifluoromethyl-carbinol or its bromophenyl analog would be able to synergize besides DDT also 1,1-Di-(p-chlorophenyl)-2,2,2-trifluoroethane or its p-bromophenyl analog. However, experimental results showed that only a negligible synergistic effect was obtained. Both the chloro- and the bromo-carbinols showed a synergistic activity of only 1.5 for the dibromo-compound, whereas for the dichloro-analog, no synergistic effect at all was produced.

Bis-(p-bromophenyl)-trifluoromethyl-carbinol acetate showed an interesting phenomenon. It was practically non-toxic to flies for the first 48 hours after its topical application. Toxicity became manifest only 72 to 96 hours after application, whereas DDT and all other compounds tested produced insecticidal signs already 24 hours after application. Presumably, the compound is slowly changed in the insect body to a more toxic one. This new toxic compound is apparently not bis-(p-bromophenyl)-trifluoromethyl-carbinol since the insecticidal activity of this compound is considerably lower than that of the above acetate.

In the residual tests, bis-(p-chlorophenyl)-trifluoromethyl-carbinol was somewhat superior to the other synergists. Furthermore, when it was added to a DDT residue of 200 mg. per sq. foot it kept DDT active for at least 2 months, whereas at this concentration DDT alone had lost its activity after 1 week.

No study has yet been made on the mode of action of the new synergists tested. However, a preliminary experiment in which DDT was applied to the ventral thorax and bis-(p-chlorophenyl)-trifluoromethyl-carbinol to the head of flies, gave very similar mortality data, proving that the synergistic action was not due to physical factors such as enhanced penetration.

Gunther *et al.* (1954) postulate that DDT or a DDT-type molecule occupies a cavity in an apoenzyme. The synergists tested, being all structural analogs of DDT could occupy the site at which DDT is inactivated; thus DDT would be left free to exert its lethal effect on the fly.

If flies are assumed to be unable to split off hydrofluoric acid from 1,1-di-(p-chlorophenyl)-2,2,2-trifluoroethane, in analogy with the dehydrochlorination of DDT (Perry & Hoskins 1951, Perry *et al.* 1953) then this compound would show the same insecticidal activity against the "R" strain as against the "T" strain. However, it could be shown that whereas 9 micrograms of this compound applied topically to a female fly of the "T" strain produced 50% mortality, the same amount did not give any kill at all against the "R" strain. This would indicate that either the resistant fly of the "R" strain possesses an enzyme which is able to dehydrofluorinate 1,1-di-(p-chlorophenyl)-2,2,2-trifluoroethane, or that the mechanism of resistance of this strain is based on a mode of action different from dehydrofluorination.

SUMMARY.—Twenty-nine compounds structurally related to DDT were tested as DDT synergists against a slightly and a moderately resistant strain of house flies. Bis-(p-chlorophenyl)-trifluoromethyl-carbinol was found to be the most active synergist among the compounds tested.

The activity is reduced by replacement of the chlorine atoms by other halogens, alkyl, nitro and alkoxy radicals, by reduction of the carbinol to the corresponding ethane, by its esterification, by a prolongation of the aliphatic chain, or by elimination of one p-chlorophenyl group.

In the residual test, bis-(p-chlorophenyl)-trifluoro-

methyl-carbinol extended the residual effect of DDT considerably and proved to possess at least as good a synergistic effect as the best synergists reported so far.

ACKNOWLEDGMENTS.—The author wishes to express his appreciation to Dr. Ernst D. Bergmann for his advice during the course of this work. The very able laboratory assistance of Mr. E. Shaaya is gratefully acknowledged.

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Granular Baits for the Control of House Flies[1]

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The resistance of house flies, *Musca domestica* L., to residual and contact sprays of chlorinated hydrocarbon insecticides, and the discovery of organic phosphorus compounds of low mammalian toxicity are the principal factors which have promoted the development of baits for the control of these flies.

Liquid baits containing an organic phosphorus insecticide, a sweetening agent, and water are used for house fly control in many sections of the country as a result of research by Thompson *et al.* (1953), Gahan *et al* (1954a), Langford *et al.* (1954), and others. Dry baits prepared with sugar and an organic phosphorus insecticide, reported by Gahan *et al.* (1945b) to be highly effective in dairy barns, are also widely used.

However, both these types of baits have certain disadvantages. Liquid baits may dry too rapidly in hot weather or soak into absorbent surfaces. Dry sugar baits dissolve on contact with moist floors or soil and are absorbed. High relative humidity also causes sugar bait to dissolve and become less effective. Because of these limitations to liquid and dry baits studies were initiated to determine the suitability of baits with insoluble granular carriers.

METHODS.—In all tests the baits were sifted lightly from a shaker-top jar in locations where the flies were congregating. The amount of bait ranged from 25 to 200 grams depending on the area treated.

House fly populations were determined by the number of flies feeding on cloth strips (1 by 24 inches) saturated with a 50% malt-water solution. The effectiveness of the treatments was based on the difference in fly counts before and at 10 minutes, 4 hours, and 24 hours after treatment.

TESTS ON GARBAGE AND TRASH PILES.—Cornmeal baits containing 1 per cent of Diazinon or 2 per cent of malathion and 10 per cent of granulated sugar were tested in a substandard section of Orlando, Fla. Because of poor sanitation in this section heavy fly populations were found where garbage and trash were allowed to accumulate behind restaurants, markets, and homes.

The baits were prepared by mixing cornmeal with a sugar-water slurry containing an emulsion of the insecticide. Twenty-five grams of Diazinon bait was applied for 5 consecutive days to each of 65 locations, where the total count before treatment was 1,863. Nine days after the test was completed the count was 1,131 flies, and the same locations were treated for 4 consecutive days with 25 grams of malathion bait. The results of these tests are summarized in table 1.

The Diazinon bait caused satisfactory reductions of house flies 10 minutes and 4 hours after the first treat-

[1] Accepted for publication April 4, 1955. This work was conducted at the Orlando, Fla., laboratory of the Entomology Research Branch under funds allotted to the Branch by the Department of the Army.

[2] The authors acknowledge the assistance of J. H. Ringdahl in conducting the field tests and of W. C. McDuffie, under whose supervision this work was done.

Table 1.—Daily treatment with cornmeal baits containing 10 per cent of sugar and Diazinon or malathion against house flies in unsanitary locations in a substandard section of Orlando, Fla.

Time After Most Recent Treatment	Per Cent Reduction After Indicated Treatment				
	1st	2nd	3rd	4th	5th
Diazinon 1%:					
10 minutes	82	91	91	92	94
4 hours	85	90	93	93	92
24 hours	5	49	58	48	81
Malathion 2%:					
10 minutes	77	97	98	97	—
4 hours	83	97	97	98	—
24 hours	83	93	95	94	—

ment but was unsatisfactory after 24 hours. Excellent control of flies was obtained 10 minutes and 4 hours after each treatment for the remainder of the test period, but five treatments were necessary to give satisfactory control for 24 hours.

The malathion bait caused satisfactory reductions of house flies for 24 hours after the first treatment and excellent reductions throughout the remainder of the test period.

TESTS IN DAIRY BARNS.—Tests were conducted in unscreened dairy barns to evaluate several bait formulations for the control of house flies. Malathion baits were prepared by mixing 2 per cent each of technical malathion and peanut oil and 10 per cent of powdered sugar with sand or cornmeal, or mixtures of the two in the ratios of 1 to 1, 1 to 3, and 3 to 1. Chlorthion baits were prepared in the same manner but contained 2 per cent of Chlorthion and 10 per cent of powdered sugar on sand or 1 per cent of Chlorthion and 10 per cent of honey on cornmeal. The amount of bait applied ranged from 50 to 200 grams, or approximately 1 gram for each 20 square feet. Each test consisted of a single treatment, but the treated barns were used for additional tests as soon as the count of flies rose to 50 or more. The results of these tests are summarized in table 2.

All the malathion baits gave excellent reductions of flies at all counts, and there was little consistent difference between the formulations. The bait containing 2 per cent of Chlorthion on sand was as effective as the malathion baits and considerably more effective than 1 per cent of Chlorthion in cornmeal.

Table 2.—Effectiveness of single treatments with malathion and Chlorthion dry baits for the control of house flies in dairy barns.

Insecticide[a] and Carrier	Number of Tests	Per Cent Reduction After—					
		10 Minutes		4 Hours		24 Hours	
		Range	Average	Range	Average	Range	Average
Malathion:							
Sand	7	90–99	94	89–99	97	81–99	93
Cornmeal	1	—	89	—	98	—	97
Sand-Meal							
1:1	4	87–98	94	95–99	98	78–99	92
3:1	1	—	99	—	99	—	92
1:3	1	—	98	—	99	—	97
Chlorthion:							
Sand	2	96–98	97	98–99	99	98–98	98
Cornmeal	8	—	—	62–98	84	31–96	56

[a] All baits contained 2 per cent of the insecticide except the Chlorthion cornmeal bait, which contained 1 per cent.

SUMMARY.—In tests against house flies, *Musca domestica* L., on garbage and trash piles in a substandard section of Orlando, Fla., cornmeal bait containing 2 per cent of malathion and 10 per cent of granulated sugar gave satisfactory control after one treatment and excellent control was maintained with daily applications during a 4-day test period. Similar bait containing 1 per cent of Diazinon gave excellent control 10 minutes and 4 hours after the second treatment but five treatments were necessary to give satisfactory reductions after 24 hours.

In unscreened dairy barns baits containing 2 per cent each of malathion and peanut oil and 10 per cent of powdered sugar on carriers of sand or cornmeal or mixtures of the two were highly effective, and about equal to bait containing 2 per cent of Chlorthion and 10 per cent of powdered sugar on sand. Bait containing 1 per cent of Chlorthion and 10 per cent of honey on cornmeal was less effective.

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ANNUAL REVIEW OF ENTOMOLOGY
VOLUME 1.

Orders for Volume 1 placed after January 1, 1956 should be sent to Annual Reviews, Inc., Stanford, California.

Control of the Sweetpotato Weevil and Several Insects Attacking Roots of Sweet Potatoes in the Field[1]

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The sweetpotato weevil, *Cylas formicarius elegantulus* (Sum.), since its discovery in New Orleans, Louisiana in 1875 has become the most serious insect pest of sweet potatoes in the United States. The insect is often considered of importance largely from a quarantine point of view. However, this is not altogether correct since the pest has become so abundant and destructive throughout south Louisiana outside of the state regulatory control areas that it is virtually impossible to produce sweet potatoes suitable for table use. The infestation in the roots often approaches 100 per cent in the field. The insect is also important in storage, and development and damage continue during the curing process and storage. It is therefore important to the Louisiana sweet potato crop from both quarantine and economic points of view. Damage by the insect in the compulsary control areas is estimated at 12.5 per cent of the crop (Cockerham *et al.* 1954).

The present recommendations for control of the sweetpotato weevil are field sanitation including cleanup measures, the planting of weevil-free seed stock, fumigation of slips, roguing of host plants, rotation of fields, dusting or spraying storage houses with DDT and dusting the seed stock at harvest with DDT. The use of DDT on the seed stock is a very effective means of killing weevil adults that emerge from the seed potatoes after storage, thus preventing them from ovipositing. In spite of all the precautions taken, severe field infestation may occur after setting the slips. If control of this insect is to be complete, an effective field treatment program must be developed and put into practice.

Experimental control of the sweetpotato weevil in Louisiana by the Louisiana Agricultural Experiment Station has been under investigation for a number of years. The first field control tests were concerned with the use of poison baits prepared from fresh sweet potatoes and Paris green. Poisoned baits killed some weevils in the field and around plant beds, storage houses, etc.; however, no measurable degree of control was obtained through their use. Tests using poisoned baits for control of the sweetpotato weevil were conducted in cooperation with the former Bureau of Entomology and Plant Quarantine Sweetpotato Weevil Laboratory located in Sunset, Louisiana. The biology, seasonal history, and habits of the sweetpotato weevil were also studied in detail by the Louisiana Agricultural Experiment Station and the former Bureau of Entomology and Plant Quarantine previous to the studies reported in this paper. Results of these studies are published by Cockerham *et al.*

Field Experiments—*1951 Tests.*—The Louisiana Agricultural Experiment Station set up an experiment for control of the sweetpotato weevil through the use of calcium arsenate dust, cryolite dust and lead arsenate spray. Weekly applications of the above insecticides for a total of 8 weeks gave significant reductions in weevil infestation. Cryolite and lead arsenate treatments were less effective than calcium arsenate (Table 1). Individual plots were $\frac{1}{16}$ acre in area and treatments were replicated four times. The unit 1 selection of the Puerto Rican variety was used in all the insecticide tests. It is the most widely planted and most popular variety grown in the State. Calcium arsenate was observed to cause minor marginal leaf burns, but not enough damage to cause concern or to adversely affect yield. Since this test in 1941 calcium arsenate dust applied with hand guns at 10 pounds per acre at weekly intervals for 7 or 8 weeks has been the standard of comparison for all weevil control experiments conducted by the station.

Table 1.—Insecticides against the sweetpotato weevil. Baton Rouge, La. 1941.

Treatment[a]	Per Cent Infested		Bushels per Acre
	Crowns	Roots	
Cryolite (10 lbs. per A.)	5.5	3.3	402
Calcium arsenate (10 lbs. per A.)	0	0.7	453
Check	42.5	38.7	370
Lead arsenate (3 lbs. per 100 gallons)	14.6	8.6	367
L.S.D. at 5% level		13.4	

[a] Eight applications made at weekly intervals.

1942 Tests.—The test field in 1942 in Baton Rouge where calcium arsenate was used on various schedules failed to develop any infestation. A cooperative test with the Bureau of Entomology and Plant Quarantine Laboratory in Sunset, Louisiana, in which calcium arsenate dust was used at weekly intervals for 1 and 2 months and biweekly for 2 months at 8.6 pounds per acre showed significant reduction in infested potatoes by all the treatments over the check (Table 2). Individual plots were approximately 1/60 acre in area, and treatments were replicated four times.

Table 2.—Calcium arsenate dust applied at various intervals for control of the sweetpotato weevil. Sunset, Louisiana, 1942.

Treatment Intervals	Per Cent Roots Infested	Bushels per Acre
Biweekly—2 months (4 applications)	0.08	212
Weekly—2 months (8 applications)	0.49	247
Weekly—1 month (4 applications)	1.81	220
Check	10.77	212
L.S.D. at 5% level	7.78	

[1] Accepted for publication March 28, 1955.

Table 3.—Sweetpotato weevil control—field experiment. Baton Rouge, La. 1948.

Treatment	Infestation of: Crowns per 50 Plants	Infestation of: Pounds of Roots per Plot	Bushels per Acre
Calcium arsenate			
Weekly for 2 months	4	1.6	169
Biweekly for 2 months	4	4.6	175
Chlordane			
Soil treatment, 5 lbs./A.	1.8	1.0	185
Soil treatment, 5 lbs./A. followed by calcium arsenate dust weekly for 2 months	0.6	0.3	182
Check	12.8	9.6	159
L.S.D. at 5% level	6.3	8	

Further work on the control of the sweetpotato weevil in the field through the use of insecticides was interrupted by World War II but was resumed in 1948 at which time some of the organic insecticides were included in the tests.

1948 Tests.—A 5×5 Latin square experiment was set up using calcium arsenate dust at weekly and biweekly intervals for 2 months, chlordane at 5 pounds technical per acre applied by hand in the drill just previous to setting the slips, and chlordane at the same rate followed by calcium arsenate dust at weekly intervals for 2 months. Individual plots were approximately 1/50 acre in area. In this paper all formulations of aldrin and chlordane except the granulated materials were derived from wettable powder 25% and 50% concentrates, respectively. In this test the chlordane was pre-mixed in old pine sawdust to facilitate distribution. The required amount of chlordane concentrate was mixed in approximately 2½ cu. ft. of the sawdust. This amount of material could easily be distributed over 1 acre. The sawdust used was at least 10 years old. Table 3 gives the results of this test.

1949–1950 Tests.—The tests in 1949 comparing calcium arsenate dust with chlordane soil treatment failed to develop any infestation in the roots. However, another field on the Experiment Station Farm in which chlordane soil treatment was tested developed a heavy infestation. This test was arranged as follows: Sixteen rows each 280 feet long were used and alternate rows were treated with chlordane at the rate of 5 pounds technical per acre. The chlordane was first mixed with old sawdust and this mixture was drilled in the row by hand. The rows were opened approximately 3″ deep and covered with a rake immediately after the treatment was applied (Table 4).

The test in 1950 consisted of 5 treatments arranged in a 5×5 Latin square design. Individual plots were approximately 1/60 acre in area. Treatments used and results obtained are given in table 5.

Table 4.—Chlordane as a soil treatment for control of the sweetpotato weevil. Baton Rouge, La. 1949.

Treatment	Per Cent Crowns Infested	Average No. Pounds per Plot	Per Cent Roots Infested	Pounds Roots Infested per Plot
5 lbs. per A.[a]	35	160	17	23
Check	47	169	35	59
L.S.D. at 5% level				15

[a] Applied in a 3-inch opening in the drill and covered with soil.

Table 5.—Effects of treatments against the sweetpotato weevil. Baton Rouge, La. 1950.

Treatment	Pounds Infested Roots per Plot	Per Cent Roots Infested	Pounds per Plot	Pounds Infested Roots per A.
Calcium arsenate dust (8 weekly applications)	1	2.6	42	65
Chlordane[a]				
2 lbs. tech. per A.	1.6	3.7	42	93
5 lbs. tech. per A.	2	4.9	42	123
10 lbs. tech. per A.	1	2.2	46	61
Check	7.4	17.2	43	444
L.S.D. at 5% level	3.5		7	

[a] Pre-mixed in 6-8-8 fertilizer used at 400 lbs. per A. Drill application approximately 4 inches below the surface of the bed.

1951 Tests.—In 1951 chlordane at various dosage levels was pre-mixed in 6–8–8 fertilizer applied at 400 pounds per acre. Treatments were replicated four times in a randomized field plot experiment. The area of individual plots was approximately 1/40 acre. The fertilizer-insecticide mixtures were applied with a one-row fertilizer distributor which placed the mixtures in a band approximately 3 inches below the surface.

Observations in previous tests had shown an apparent improvement in the quality of the potato roots in plots treated with chlordane as compared with those in untreated plots or those treated with calcium arsenate. This difference was thought to be due to protection of the roots by chlordane from damage by white grubs, wireworms, banded cucumber beetle larvae, mole crickets, flea beetle larvae and perhaps other forms. Consequently the field test in 1951 was located in a field where the incidence of these insects was normally heavier than in other fields on the Experiment Station Farm in order to study the effects of chlordane at various dosage levels in producing edible roots with clean, smooth surfaces. Table 6 shows the results of this test.

1952 Tests.—The work was enlarged in scope to include aldrin. Two locations were selected for these tests. One was in Baton Rouge and the other in Avoyelles parish, Louisiana, in a field which was severely infested with white grubs, and where sweet potatoes in the immediately preceding years had suffered at least 75 per cent damage from this insect.

The Baton Rouge test consisted of a 6×6 Latin square arrangement where two dosages each of chlordane and aldrin were used as soil treatments and compared with

Table 6.—Effect of three dosage levels of chlordane in protecting sweet potato roots from damage by soil insects.[a] Baton Rouge, La. 1951.

Pounds Technical Chlordane per Acre[b]	Roots: Per Cent Damaged	Roots: Total Pounds per Plot	Roots: Bushels Undamaged per A.
1	9.6	110	208
2	6.6	117	229
5	9	113	216
Check	36	118	159
L.S.D. At 5% level	8.6	12	

[a] Including white grubs, the mole cricket, wireworms and perhaps other species. Practically no damage by the sweetpotato weevil occurred in this test.
[b] Pre-mixed and applied in 400 pounds 6-8-8 fertilzier per acre.

Table 7.—Use of chlordane, aldrin and calcium arsenate against the sweetpotato weevil. Baton Rouge, La. 1952.

Treatment (Pounds per Acre)	Per Cent Infested		Loss per Acre (Bu.)	Total Bushels per Acre
	Roots	Crowns		
Aldrin				
1	26.3	74	80	306
2	21	35	65	310
Chlordane[a]				
2	27	67	83	307
5	26	57	78	301
Calcium arsenate dust, 10 (8 weekly applications)	10.6	4	33	315
Check	36.5	64	119	327
L.S.D. at 5% level	11.2	25		

[a] Mixtures were applied in the drill before field setting.

the standard calcium arsenate dust treatment. The individual plot area was approximately 1/60 acre. The Aldrin and chlordane were pre-mixed with the fertilizer. The fertilizer was applied at the rate of 400 pounds per acre with a one-row fertilizer distributor which placed the band approximately 3 inches below the surface. The slips were set in the rows immediately after treatment. The results of this test are given in table 7.

The test in Avoyelles parish was located in a sweetpotato weevil-free area and consisted of a randomized plot arrangement of 3 treatments, each replicated 4 times. Individual plot area was approximately 1/40 acre. Treatments consisted of 5 pounds chlordane per acre, 2 pounds aldrin per acre, and a check which yielded 22.7, 10.5 and 64.5 per cent damaged roots, respectively, or significant protection of the sweet potatoes from injury by white grubs. The chemicals were pre-mixed with old sawdust. The mixtures were distributed by hand in a 4" opening in the center of the prepared bed. The opening was closed immediately after the mixtures were applied. Slips were set 1 week later.

1953 Tests.—Tests were again conducted in Baton Rouge and in Avoyelles parish. The test in Avoyelles parish was conducted with the express purpose of controlling white grubs and was set up on a farm where the white grub damage had consistently been severe. The Baton Rouge test field was treated by applying 2% granulated formulations of aldrin and chlordane by hand uniformly over the entire surface of the bed area. This was followed by a disk chopper which covered the particles 3 to 4 inches. Treatments were replicated four times. Individual plots were approximately 1/18 acre. The plots in Avoyelles parish were also treated with granulated formulations; however, they were applied broadcast over the entire plot area with a small whirlwind type hand seeder just before the rows were bedded up. This type of application gave satisfactory distribution only when the air was very calm. A swath 15 to 18 ft. wide could be uniformly treated at controlled dosages under calm conditions. Treatments were replicated four times and were made approximately 2 weeks previous to setting the slips. Individual plots were approximately 1/8 acre in area. Table 8 shows the results from these tests.

1954 Tests.—The tests were conducted in Baton Rouge at two locations. Test 1 was located on the University Hill Farm where aldrin at 1, 2 and 3 pounds per acre, from 2% granulated material, were used as bed treatments, and 1½ pounds per acre was pre-mixed with the fertilizer and applied in the drill. Calcium arsenate

Table 8.—Granulated aldrin and chlordane as soil treatments and calcium arsenate dust for protection of sweet potato roots from insect damage. Baton Rouge, La. 1953.

Treatment	Per Cent Roots Damaged by			
	Sweetpotato Weevil		Soil Insects	
	1953	*1954*	*1953*	*1954*
Chlordane[a]	9	43.5	5.7	2
Calcium arsenate dust (8 weekly applications at 10 lbs. per A.)	4.5	—	18	—
Aldrin[a]	4.8	32.8	0.5	1
Check	12.2	50.4	13.5	33
L.S.D. at 5% level	7.2	10.3	6.2	10

[a] Used 2% granulated material; applied 3 pounds technical material per acre.

dust at weekly intervals for 8 weeks and an untreated check were also included in the test. Treatments were replicated four times. Individual plots were approximately 1/30 acre in area. No weevil infestation nor miscellaneous soil insect damage developed in this test. The yields were approximately equal in all treatment).

Test 2 was a study of the residual action of aldrin and chlordane for control of the sweetpotato weevil and the miscellaneous soil insects responsible for damage to the edible roots. This study was made by utilizing the identical plots which were treated 1 year previously. The plot rows were so handled that soil from one row was not mixed with the soil from any other row. Since these plots ran the entire length of the field (225 ft.) it was possible to re-work the rows in their original position without disturbing adjacent rows. Treatments were replicated four times. Individual plots were approximately 1/18 acre in area. Results of these tests are also presented in table 8.

Insecticide Residues.—Chemical analyses of the edible roots of sweet potatoes grown in chlordane- and aldrin-treated soils were made by the Velsicol Corporation and the Shell Chemical Corporation, respectively. The method of analysis used for chlordane was the Modified Davidow. The method used for aldrin was the colorimetric phenyl azide. Results of these analyses were as follows: potatoes grown where chlordane was used at 2 and 5 pounds per acre in the 1951 crop contained 0.04 and 0.057 p.p.m. chlordane, respectively. Those grown where a 2-pound dosage per acre was used in the 1952 crop showed no chlordane. Potatoes grown in soil treated with aldrin at 2 pounds per acre in the 1952 crop showed no aldrin.

Discussion of Results.—The 11 field experiments reported herein were conducted between 1941 and 1954 and were designed to develop a practical means of field control for the sweetpotato weevil, as well as for several miscellaneous soil insects which damage the edible roots in the field. Although this work was conducted in a severely infested sweetpotato weevil area, there were occasions when the infestations were too low to evaluate treatments and the results of such tests are not reported. A general study of the tables shows that calcium arsenate applied as a dust at the rate of approximately 10 pounds per acre at weekly intervals for 8 weeks beginning approximately 10 days after the slips were set in the field

gave significant control of the sweetpotato weevil in every test. The applications were ceased after a period of approximately 2½ months following field setting. By this time the vines were usually well matted in the middles and the small edible roots were beginning to develop. After the roots reach sufficient size the soil around the crowns begins to crack, thus opening a very convenient means of entrance to the roots themselves by the adult weevils. It is at this time that the greatest amount of field damage occurs to the edible roots. The extent of soil cracking is determined by such factors as soil moisture during the time of root development, bed preparation and cultivation, soil types and structures, and the variety of sweet potato being grown. Some varieties produce much larger roots than others and thus cause larger cracks. Other varieties may produce small roots which are located quite near the surface and which are often exposed. This condition presents the ideal situation for field infestation of the roots by the sweetpotato weevil. Seasons when soil cracking is at a minimum are coincident with low field infestation in the roots.

Chlordane as a soil insecticide for control of soil borne insects was first used in this study in 1948. It was applied in a 3-inch trench in the drill just previous to setting the slips. A wettable powder, 50% concentrate, was mixed with old pine sawdust to facilitate distribution. This method of mixing and application proved very convenient for experimental field use where the material was applied by hand. All soil treatments were covered immediately with soil after being applied. The results of the test in 1948 (Table 3) showed that chlordane used as a soil treatment at the rate of 5 pounds technical per acre was as effective as the calcium arsenate dust treatment. Chlordane soil treatment followed by eight applications of calcium arsenate dust resulted in practically weevil-free potatoes. Subsequent field tests using chlordane as a soil treatment showed that the degree of protection afforded the roots by this treatment apparently depended upon the severity of the infestation. In 1948 the average field infestation was 12 per cent. When the infestation was greater, the degree of control was lessened. Table 4, which presents the results of a test conducted in 1949, shows this quite clearly. Under a heavy field infestation of 35 per cent, chlordane at 5 pounds per acre reduced this figure to 17 per cent.

The degree of control secured through the use of chlordane was not correlated with dosage. Table 5 shows the results of a test in 1950 in which it was used at 2. 5 and and 10 pounds per acre. All three dosages significantly reduced the infestation approximately the same. Potatoes produced in the chlordane-treated plots during 1950 were first observed to be relatively free of damage caused by soil insects other than the sweetpotato weevil. A potato which grades number 1 in other respects is thrown out of this class if the surface shows insect damage.

The scope of this study was therefore enlarged in 1951 to include possible control of species responsible for damaging the edible roots of sweet potatoes in the field. The number of species of insects which damage sweet potato roots and their relative importance is not fully understood at the present time. There is need for much work on species involved, their biologies, ecological factors affecting populations, etc. However, to date we know that much of this damage is caused by white grubs, wireworms, larvae of the banded cucumber beetle, mole crickets and flea beetle larvae.

Table 6 shows the protection afforded developing sweet potato roots from damage by soil insects by chlordane soil treatment. Chlordane-treated plots were significantly better than the checks. Treatments at 1, 2 or 5 pounds per acre were equally effective and reduced damage by this group of insects from 36 per cent to an average of 8 per cent. This test resulted in an increase of 60 crates of undamaged potatoes per acre.

The use of aldrin as a soil poison in this study was begun in 1952. Table 7 shows that it significantly reduced infestation by the weevil when used at 2 pounds technical per acre. Chlordane in the 1952 test at 2 or 5 pounds per acre reduced the weevil infestation but not significantly. In this test 1 pound of aldrin per acre was as effective as 2 or 5 pounds of chlordane in effecting weevil control. In another test in 1952 conducted in Avoyelles parish in an area where white grubs normally damaged greater than 50 per cent of the crop, aldrin at 2 pounds per acre was superior to chlordane at 5 pounds in reducing this type of damage. Aldrin-treated plots contained 10% damaged roots, whereas the chlordane plots contained 22% damage and the untreated plots were 64% damaged. The following year (1953) another test was conducted on the same farm in Avoyelles parish where chlordane, aldrin and heptachlor were compared for effectiveness in protecting sweet potato roots from white grub damage. Chlordane at 3 pounds and aldrin and heptachlor at 2 pounds each per acre reduced damage significantly. Damaged potatoes were reduced from 25 per cent in the check to 4.5 per cent in the treated plots. Chlordane at 1 pound per acre did not significantly reduce the injury. The materials in this test were granulated formulations and were applied broadcast with a whirlwind-type hand seeder. Immediately after application the plots were disked and bedded.

Table 8 shows comparisons between chlordane and aldrin each applied at 3 pounds per acre and 8 applications of calcium arsenate dust. Aldrin soil treatment and calcium arsenate dust significantly reduced the infestation by the sweetpotato weevil and were equally effective. The chlordane soil treatment was not significant in reducing the weevil infestation. The edible roots from aldrin-treated plots contained 0.5% damage by soil insects as compared to 6% damage in the chlordane treatment and 14% in the check. Both treatments were significantly better than the check or the calcium arsenate treatment in reducing soil insect damage to the roots. The same plots were maintained for a study of the residual effectiveness of the soil treatments in 1954 (Table 8). At the time the field was set in 1954 the insecticides had been in the soil 1 year, and the rows had been chopped and re-worked before planting. Roots infested by the sweetpotato weevil were reduced from 50% in the check to 33% in the aldrin treatment and to 44% in the chlordane treatment. This reduction in damage by both treatments was significant over the check; however, such a reduction is of little or no practical value. Two per cent of the roots showed damage by soil insects in the

chlordane plots, 1 per cent in the aldrin plots and 33 per cent in the check, indicating that both aldrin and chlordane gave equally good protection against these insects the second year following treatment.

To date no adverse effects on plant development or yield have been obtained in the tests where chlordane or aldrin have been used as soil treatments for sweet potatoes. These studies show a tendency for aldrin to be somewhat superior to chlordane in the protection of the roots from damage by the sweetpotato weevil and the several soil insects responsible for marring the quality of the edible roots. The chemicals have been used as concentrated powders mixed in old sawdust and in the fertilizer, and as granulated formulations. All formulations were apparently equally effective in protecting the edible potato roots. Additional study is needed on application methods, techniques, and dosage levels.

No reports of any off-flavor have been received from persons eating potatoes grown in the plots treated with aldrin or chlordane.

SUMMARY.—The results of 11 field experiments conducted during 1941–1954 and designed to develop practical methods for the control of the sweetpotato weevil and several soil inhabiting insects which damage the roots of sweet potatoes in the field showed that calcium arsenate dust applied weekly for 8 weeks consistently gave significant reductions in sweetpotato weevil infestations. Chlordane and aldrin used as soil treatments applied in the drill gave considerable protection to the roots from damage by the sweetpotato weevil. Drill or broadcast applications of chlordane or aldrin gave consistently significant reduction in damage to the roots by soil insects which feed on and damage sweet potato roots in the field. Heptachlor gave good protection from white grub damage in the one field test in which it was used. Aldrin tended to offer a higher degree of protection than chlordane. Aldrin was used at the rate of from 1 to 3 pounds technical per acre and chlordane at the rate of from 1 to 10 pounds per acre. The materials were applied mixed in old sawdust or in the fertilizer, and in granulated form. The method used seemed to have little if any effect on the control obtained. Chlordane and aldrin were equally effective against the sweetpotato weevil and several soil insects the second year after treatment. Although damage by the sweetpotato weevil was reduced significantly, under conditions of heavy infestation control was not good enough to be of much practical value.

The above-ground portions of the developing plant were not damaged nor was yield affected in any of the tests with aldrin or chlordane. Calcium arsenate often caused minor marginal leaf burn but never affected yields. No off-flavor was detected in the potatoes grown in soils treated with chlordane or aldrin.

Analyses of the edible roots grown in chlordane- and aldrin-treated soils showed a maximum of 0.057 p.p.m. chlordane where used at 5 pounds per acre, and no aldrin where it was used at 2 pounds per acre.

REFERENCE CITED

Cockerham, K. L., O. T. Deen, M. B. Christian and L. D. Newsom 1954. The Biology of the Sweetpotato Weevil. La. Agr. Expt. Sta. Tech. Bull. **483.**

Filth Flies of Central Alaska[1]

GORDON D. GILL[2]

Since World War II there has been increased activity in the investigation of arthropods of potential medical importance in Alaska. Considerable data on biting flies were gathered by the investigators of the Alaska Insect Control Project of 1947–1948, and the entomologists of the Arctic Health Research Center, Anchorage, have been continuing studies on these flies. In 1950 a project was initiated by the Arctic Aeromedical Laboratory at Ladd Air Force Base, Fairbanks, to investigate potential disease vectors in the Territory. During 1952–1954 the author, while serving with the Air Force in Alaska, was assigned to this project.

Despite the aforementioned interest in medical entomology in Alaska, relatively little has been published concerning the filth-feeding and filth-breeding Diptera of the Territory, although the lack of adequate sewage and garbage disposal frequently produces filth flies in abundance. Certain diseases, such as salmonellosis and echinococcosis, are known to occur in Alaska, and filth flies may sometimes play a role in the transmission of these diseases. Schiller (1954), in his investigations of echinococcosis in Alaska, has demonstrated experimentally that the black blow fly, *Phormia regina* (Meig.), is able to transmit the helminth eggs to an intermediate host.

Coquillett (1900), Malloch (1919, 1923) and Weber (1950) published reports on general collections of Alaskan Diptera, from which a few records of species known to feed or breed in filth may be obtained. Sailer & Lienk (1951) made a series of blow fly collections at Anchorage and Fairbanks during the summer of 1948,

[1] Accepted for publication April 7, 1955. This study was made as a part of Air Force Project 22-1401-0004, under the supervision of Lt. Col. Andres I. Karstens, Commander, Arctic Aeromedical Laboratory, Ladd Air Force Base, Alaska. The data contained in this paper are taken largely from Project Report Number Two, October 1954. It will be noted that a number of flies listed in this paper probably should not be considered filth flies. For completeness, however, records on all species identified from trapped material are included. Species collected by means other than trapping have also been included if they occur in families which commonly have coprophagous or sarcophagous forms.

[2] The author is indebted to Dr. Maurice T. James and Dr. H. C. Huckett for the invaluable aid given in the determination of much of the material upon which this paper is based. A/1C Benjamin Zuckerman and A/1C Johnnie Trickle assisted in the collection of flies from a number of localities.

and not only presented their trapping results, but summarized the known distribution for Calliphoridae in Alaska. This was prompted by their observation that "published information concerning blow flies in Alaska is scanty and consists, for the most part, of species descriptions or distribution records buried in publications having no direct reference to Alaska."

The observation of Sailer and Lienk might well hold true for other filth flies, and thus it is the purpose of this paper to make available a list of filth fly records, together with some trapping data which may give a clue to the relative abundance of certain forms.

METHODS.—The collections were made for the most part during the spring and summer of 1953. Screen-wire flytraps, $9'' \times 6\frac{1}{2}'' \times 6\frac{1}{2}''$, were used. It was not possible to standardize collections with respect to weather, time of exposure of the traps, proximity of other attractants, etc. Despite this shortcoming, the author was able to visit a number of localities in central and northern Alaska (Fig. 1), and many opportunities for collecting presented themselves.

At each site visited, at least two traps were usually set, one baited with beef liver and one with excrement. Sometimes traps with different baits were used in addition to these, with the hope of attracting a greater variety of species. The flies collected on each occasion were examined under magnification and those which occurred in large numbers and were fairly easy to recognize were tabulated. All specimens which could not be readily recognized were mounted, as were generous samples of the forms already tabulated. All collections were assigned lot numbers and stored for later re-examination and distribution to specialists. For the most part, specimens on which the data in the accompanying list of species are based were deposited in the collection of the State College of Washington.

FIG. 1.—Map of Alaska, showing localities at which filth fly collections were made.

Table 1.—Total flies collected in traps baited with excrement (A) or with beef liver and carrion (B).

		April	May	June	July	August	September	Total
Acalypteratae	(A)	76	11	7	3	4	0	101
	(B)	59	1	4	1	5	0	70
Calliphoridae	(A)	86	1,606	490	152	89	64	2,487
	(B)	26,500	369	2,234	855	350	490	30,798
Scopeumatidae	(A)	0	13	12	0	39	12	76
	(B)	0	0	3	0	15	0	18
Muscidae	(A)	33	487	866	544	54	14	1,998
	(B)	26	29	362	100	125	58	700
Others	(A)	0	2	3	6	9	0	20
	(B)	1	8	5	2	4	0	20

TRAPPING RESULTS.—Because of the lack of standardization of the previously mentioned factors which would influence trapping results, one might not ordinarily offer tabulations of the flies taken in traps. However, since so little information on Alaskan forms is available, such tabulations seem advisable in this case.

From table 1 it will be seen that the Calliphoridae and Muscidae (including Anthomyiidae) far outnumbered the flies of other groups. Therefore, a further analysis is presented only for these two families. Since localized abundance of certain forms may give misleading results when only the total number of flies collected is considered, table 4 has been included to show the frequency of occurrence of certain flies in collections.

In table 2 the large number of calliphorids trapped in April resulted mainly from a series of collections made during the last week of this month at Ladd Air Force Base by Johnnie Trickle. Practically all of the specimens were examined under magnification by the author by spreading small portions in petri dishes. *Protophormia terrae-novae* was so abundant that only an approximation could be made of the number collected. There appeared to be about 20,000 flies of this species among those trapped by Trickle. The method of determination might be questioned, but *P. terrae-novae* is fairly easy to

Table 2.—Calliphoridae collected in traps baited with excrement (A) or with liver and carrion (B).

		April	May	June	July	August	September	Total
Calliphora	(A)	0	0	0	1	0	3	4
morticia	(B)	0	0	1	9	4	15	29
terrae-novae	(A)	0	2	2	75	3	23	105
	(B)	0	0	31	25	24	116	196
vomitoria	(A)	0	1	6	4	8	10	29
	(B)	0	0	130	30	11	64	235
Cynomyopsis	(A)	0	2	4	2	37	6	51
cadaverina	(B)	0	23	162	136	217	88	626
Francilia	(A)	0	0	0	0	0	0	0
alaskensis	(B)	0	1	43	3	1	0	48
Lucilia	(A)	0	1	89	33	1	1	125
illustris	(B)	0	0	487	474	75	20	1,056
Protophormia	(A)	86	1,600	389	36	40	20	2,171
terrae-novae	(B)	26,500	324	1,375	174	14	184	28,571
Other or undetermined calliphorids	(A)	0	0	0	1	0	1	2
	(B)	0	1	5	4	4	3	17

Table 3.—Muscidae collected in traps baited with excrement (A) or with liver and carrion (B).

		April	May	June	July	August	September	Total
Fannia sp.	(A)	0	29	33	33	9	1	105
	(B)	0	0	237	12	19	13	281
Hydrotaea sp.	(A)	0	0	15	3	6	0	24
	(B)	0	0	44	0	47	10	101
Muscina assimilis	(A)	8	81	29	16	0	0	134
	(B)	22	16	12	4	0	0	54
Muscina stabulans	(A)	0	0	0	9	9	4	22
	(B)	0	0	0	0	0	9	9
Mydaea spp.	(A)	0	0	18	1	0	0	19
	(B)	0	0	6	0	0	0	6
Myospila meditabunda	(A)	0	0	88	5	1	0	94
	(B)	0	0	4	0	3	0	7
Paregle spp., etc.	(A)	0	369	244	468	27	8	1,116
	(B)	3	4	33	81	45	25	191
Pyrellia cyanicolor	(A)	25	3	424	0	0	0	452
	(B)	1	0	16	0	0	0	17
Others or undetermined muscids	(A)	0	4	17	7	2	1	31
	(B)	0	9	10	3	11	1	34

Table 4.—Frequency of occurrence of certain flies in collections.

	Human Feces (17)	Bear Feces (8)	Beef Liver (15)	Carrion (14)	Total (54)
Calliphoridae					
Calliphora morticia	1	1	2	3	7
Calliphora terrae-novae	5	2	9	6	22
Calliphora vomitoria	3	3	10	5	21
Cynomyopsis cadaverina	6	5	11	9	31
Eucalliphora lilaea	1	1	3	3	8
Francilia alaskensis	1	0	5	4	10
Lucilia illustris	8	2	11	6	27
Protophormia terrae-novae	15	7	15	12	49
Muscidae					
Azelia spp.	2	0	0	1	3
Fannia spp.	8	1	5	5	19
Fucellia spp.	1	2	1	0	4
Graphomya maculata	3	0	2	1	6
Helina spp.	3	0	0	0	3
Hydrotaea spp.	5	1	3	6	17
Hylemya spp.	5	3	4	6	18
Muscina spp.	8	5	7	10	30
Mydaea spp.	3	0	0	1	4
Myospila meditabunda	5	2	1	4	12
Paregle spp.	9	5	3	6	23
Pegomya spp.	2	1	2	3	8
Pyrellia cyanicolor	6	1	0	3	10

recognize and appeared to be the only blow fly present. These flies had evidently hibernated in great numbers through the winter and were quite troublesome at this time. *P. terrae-novae* was by far the most abundant and widespread blow fly collected during 1953. Sailer and Lienk considered this species most likely to have public health significance in Alaska.

In table 3 most of the *Pyrellia cyanicolor* collected during June were trapped by Benjamin Zuckerman at Minchumina. In this table it will be noted that "*Paregle* spp., etc." has been used. It was not always possible satisfactorily to separate *Paregle* and related genera such as *Egle*, *Hylemya* and *Pegomya*. Although *Paregle* seemed to be the most common, this group includes all flies of the genera mentioned. In table 4 *Paregle* and *Pegomya* were tabulated only when determinations were made or confirmed by Dr. James or Dr. Huckett.

The absence of *Musca domestica* from the 1953 collections will be noted, although this species has been recorded from Alaska (James 1947) and the Mackenzie River Basin of Canada (Dutilly 1946). Aldrich (1922), who devoted attention to filth flies during the Smithsonian Institution's Entomological Expedition to Alaska in 1921, wrote:

"The common house fly was not found at any point in Alaska. Continuous attention was given to this matter, and collections were made at garbage dumps in Anchorage and Seward; while at Ketchican (sic), the southernmost town in Alaska, grocery stores, restaurants and a cannery were carefully examined early in August without finding any of the flies."

Although the Alaskan species of filth flies are similar to those one might collect in more temperate areas, the relative abundance of certain forms appears to differ in certain respects. It is possible that increased settlement in the Territory may affect the filth fly fauna, and the tabulations presented here may form a basis for comparison with future studies.

LIST OF SPECIES.—In the following list the initials of the workers who identified specimens from each locality are given in parentheses. These initials are GDG (Gordon D. Gill), HCH (H. C. Huckett), MTJ (Maurice T. James) and WWW (Willis W. Wirth). The writer has included his determinations only for those localities from which specimens were not forwarded to specialists. In all cases the latter determinations are for species which have previously been reported from Alaska. Localities and dates are only those recorded in the author's collections and do not necessarily indicate complete Alaskan distribution records. Dates are 1953 unless otherwise indicated.

TEPHRITIDAE

An unidentified specimen of this family was collected in a trap baited with human excrement at Fort Yukon on 14 July.

PIOPHILIDAE

Piophila affinis Meigen. Birch Lake (MTJ), Circle Hot Springs (MTJ); August; from garbage dump and from trap baited with human excrement.

Piophila nigriceps Meigen. Ladd Air Force Base (MTJ); 3 June; on well-rotted carrion.

Piophila sp. Nome (MTJ); 22 August; store window.

DROSOPHILIDAE

Drosophila funebris (Fabricius). Ladd Air Force Base (WWW & MTJ); 10 September 1952, January 1953; reared from larvae found in excrement of laboratory rats.

CHLOROPIDAE

Thaumatomyia annulata (Walker). Ladd Air Force Base (MTJ), Rapids (MTJ); April–May; traps baited with fruit-milk mixture and with human excrement.

SEPSIDAE

Themira putris (Linnaeus). Minchumina (MTJ); 4 June; trap baited with beef liver.

SPHAEROCERIDAE

Copromyza equina Fallén. Paxson (MTJ); 27 May; trap baited with human excrement.

Leptocera exiguella Spuler. Fairbanks (MTJ), Ladd Air Force Base (MTJ); July, September; window of dairy-barn, animal room of laboratory.

Leptocera fontinalis (Fallén). Nome (MTJ); 22 August; store window.

Leptocera sp. Bethel (MTJ); 3 September; random collecting.

HELEOMYZIDAE

Acantholeria abnormalis Garrett. Paxson (MTJ); 7 May; collected indoors by Dr. L. L. Hufman.

?Anypotacta aldrichii (Garrett). Ladd Air Force Base (MTJ); 19 April; trap baited with human excrement.

Heleomyza brachypterna (Loew). Ladd Air Force Base (MTJ), Livengood (MTJ), Paxson (MTJ), Rapids (MTJ); April-May; random collecting.

Heleomyza serrata (Linnaeus). Ladd Air Force Base (MTJ), Rapids (MTJ); 9 September 1952, April 1953; traps baited with excrement.

Heleomyza sp. Ladd Air Force Base (MTJ), Paxson (MTJ); April–May; traps baited with human excrement.

Heteromyza oculata Fallén. Livengood (MTJ); 13 May; inside abandoned cabin.

Morpholeria tristis (Loew). Rapids (MTJ); 26 April; random collecting.

Neoleria fuscolinea (Garrett). Birch Lake (MTJ), Circle (MTJ), Fort Yukon (MTJ), Ladd Air Force Base (MTJ); April–August; traps baited with excrement and carrion.

Neoleria tibialis (Zetterstedt). Ladd Air Force Base (MTJ); 13 September 1952; garbage area.

Neoleria sp. Ladd Air Force Base (MTJ), Nome (MTJ); July–August; trap baited with excrement, store window.

Oecothea fenestralis (Fallén). Nome (MTJ); 24 August; trap baited with beef liver.

Scoliocentra tincta (Walker). Ladd Air Force Base (MTJ), Livengood (MTJ), Nome (MTJ), Rapids (GDG); April–August; traps baited with beef liver and excrement.

DRYOMYZIDAE

Dryomyza dayi Cresson. Central (MTJ); 24 June; trap baited with human excrement.

SARCOPHAGIDAE

Sarcophaga harpax Pandellé. Fort Yukon (MTJ), Minchumina (MTJ); June–July; traps baited with beef liver and hare entrails. This species is included by James (1947) in a group of closely related species of *Sarcophaga* which have been reported to be involved in human myiasis. He states that *S. harpax* is widespread, but that records are not abundant. Alaska was not included in the distribution given by James.

Sarcophaga scoparia Pandellé. Paxson (MTJ); 19 August; trap baited with human excrement.

Sarcophaga spp. Minchumina (MTJ), Paxson (MTJ); June–August; traps baited with human excrement and the carcass of a hare.

Ravinia l'herminieri (Robineau-Desvoidy). Circle (MTJ); 21 August; trap baited with hare carcass.

Wohlfahrtia opaca (Coquillett). Minchumina (MTJ); 4 June; trap baited with beef liver.

Wohlfahrtia vigil (Walker). Ladd Air Force Base (MTJ); 9 June; trap baited with bear excrement. *Wohlfahrtia* is suspected of having veterinary importance in the Fairbanks area and might be a potential danger to young babies. The author received reports of at least seven cases of cutaneous myiasis in puppies during the summer of 1953, but was given larvae from only one case. These larvae appeared to be *Wohlfahrtia*, but were already preserved and could not be reared.

CALLIPHORIDAE

Acronesia aldrichia (Shannon). Galena (MTJ); 25 July; trap baited with beef liver.

Acronesia anana Hall. Umiat (MTJ); 31 July; trap baited with beef liver.

Acronesia popoffana (Townsend). Galena (MTJ), Nome (MTJ), Umiat (MTJ); July–August; traps baited with beef liver.

Calliphora morticia Shannon. Central (MTJ), Circle (MTJ), Galena (MTJ), Ladd Air Force Base (MTJ), Paxson (MTJ); June–September; traps baited with beef liver, carrion, and excrement.

Calliphora terrae-novae Macquart. Bethel (MTJ), Central (MTJ), Circle (MTJ), Circle Hot Springs (MTJ), Fort Yukon (GDG), Galena (MTJ), Ladd Air Force Base (MTJ), McGrath (MTJ), Minchumina (MTJ), Nome (MTJ), Paxson (MTJ); June–September; traps baited with beef liver, carrion and excrement.

Calliphora vomitoria (Linnaeus). Bethel (MTJ), Birch Lake (GDG), Central (MTJ), Circle Hot Springs (GDG), Fort Yukon (GDG), Galena (MTJ), Ladd Air Force Base (MTJ), Minchumina (MTJ), Nome (MTJ), Paxson (MTJ), Umiat (MTJ); May–September; traps baited with beef liver, carrion and excrement.

Cynomya mortuorum (Linnaeus). Bethel (MTJ); 3 September; trap baited with beef liver.

Cynomyopsis cadaverina (Robineau-Desvoidy). Bethel (MTJ), Central (GDG), Circle (GDG), Circle Hot Springs (GDG), Fort Yukon (GDG), Galena (GDG), Ladd Air Force Base (MTJ), Minchumina (MTJ), Nome (GDG), Paxson (MTJ), Umiat (MTJ); May–September; traps baited with beef liver, carrion and excrement.

Eucalliphora lilaea (Walker). Central (MTJ), Fort Yukon (MTJ), Ladd Air Force Base (MTJ), Minchumina (MTJ), Paxson (MTJ); May–September; traps baited with beef liver, carrion and excrement. This species has not previously been recorded from Alaska as far as the author can determine at the present time. It was not included by Sailer & Lienk (1951).

Francilia alaskensis Shannon. Central (MTJ), Fort Yukon (MTJ), Minchumina (MTJ), Paxson (MTJ); May–July; traps baited with beef liver, carrion and human excrement.

Lucilia illustris (Meigen). Central (GDG), Circle (GDG), Circle Hot Springs (GDG), Fort Yukon (GDG),

Galena (GDG), Ladd Air Force Base (MTJ), Minchumina (MTJ), Paxson (GDG), Umiat (MTJ); May–September; traps baited with beef liver, carrion and excrement.

Protocalliphora avium Shannon & Dobroscky. Ladd Air Force Base (MTJ); 19 May; trap baited with human excrement. Although another bird-nest screw-worm, *Protocalliphora sapphira* (Hall) is known from Alaska, apparently this is the first Alaskan record for *P. avium*.

Protophormia terrae-novae (Robineau-Desvoidy). Bethel (GDG), Birch Lake (GDG), Central (MTJ), Circle (GDG), Fort Yukon (GDG), Galena (GDG), Ladd Air Force Base (MTJ), Livengood (MTJ), Minchumina (MTJ), Nome (GDG), Olnes (GDG), Paxson (MTJ), Rapids (MTJ), Umiat (GDG); April–September; traps baited with beef liver, carrion, excrement and fruit-milk mixture; reared from larvae taken from carcass of dog.

SCOPEUMATIDAE

Scopeuma furcatum (Say). Bethel (MTJ), Central (MTJ), Circle (GDG), Circle Hot Springs (GDG), Nome (GDG), Paxson (MTJ); May–September; traps baited with beef liver, carrion and excrement.

Microprosopa haemorrhoidalis (Meigen). Nome (MTJ), Paxson (MTJ); June–August; random collecting.

MUSCIDAE (INCLUDING ANTHOMYIIDAE)

Alliopsis sp. Paxson ("Ten-Mile Lake") (MTJ); 7 September 1952; garbage dump.

Alloeostylus diaphanus (Wiedemann). Central (MTJ); 24 June; trap baited with human excrement.

Anthomyia pluvialis (Linnaeus). Ladd Air Force Base (MTJ); June–July; traps baited with beef liver and dog excrement.

Azelia cilipes Haliday. Central (HCH), Galena (HCH); June–July; traps baited with beef liver and human excrement.

Azelia triquetra (Wiedemann). Ladd Air Force Base (HCH); 8 July; trap baited with human excrement.

Azelia zetterstedti Rondani. Circle (HCH); 19 August; trap baited with entrails of a hare.

Coelomyia spathulata (Zetterstedt). Nome (HCH); 22 August; store window.

Egle muscaria (Fabricius). Minchumina (HCH); 4 June; trap baited with beef liver.

Fannia aethiops Malloch. Minchumina (HCH); 9 June; traps baited with human excrement.

Fannia canicularis (Linnaeus). Central (MTJ), Circle Hot Springs (MTJ), Fort Yukon (HCH), Fairbanks (MTJ), Ladd Air Force Base (MTJ), Minchumina (MTJ); May–September; traps baited with beef liver, carrion and excrement.

Fannia fuscula (Fallén). Central (HCH), Ladd Air Force Base (MTJ), Minchumina (HCH & MTJ); June–July; traps baited with beef liver and excrement.

Fannia manicata (Meigen). Birch Lake (MTJ), Circle Hot Springs (MTJ), Fairbanks (MTJ), Fort Yukon (MTJ), Ladd Air Force Base (MTJ), Paxson (MTJ); May–September; traps baited with beef liver, carrion and excrement.

Fannia postica (Stein). Galena (HCH); 25 July; trap baited with beef liver.

Fannia spathiophora Malloch. Central (MTJ); June; traps baited with entrails of a hare.

Fucellia antennata Stein. Nome (MTJ); August; traps baited with beef liver and excrement.

Fucellia ariciiformis Holmgren. Nome (HCH); 22 August; store window.

Fucellia fucorum (Fallén). Nome (MTJ); 22 August; store window.

Fucellia pictipennis Becker. Minchumina (MTJ), Rapids (MTJ); April–June; traps baited with human excrement and entrails of a hare.

Graphomya maculata (Scopoli). Central (MTJ), Fort Yukon (MTJ), Ladd Air Force Base (MTJ), Paxson (GDG); June–July; traps baited with beef liver, carrion and excrement.

Hebecnema nigricolor (Fallén). Central (HCH); 24 June; trap baited with human excrement.

Helina duplicata (Meigen). Central (MTJ), Ladd Air Force Base (MTJ); June; traps baited with excrement.

Helina fulvisquama (Zetterstedt). Paxson (HCH); 19 July; trap baited with human excrement.

Helina obscuripes (Zetterstedt). Paxson (MTJ); 27 May; trap baited with human excrement.

Hydrophoria katmaiensis Malloch. Nome (HCH); 23 August; trap baited with beef liver.

Hydrotaea bispinosa (Zetterstedt). Ladd Air Force Base (HCH), 28 July; trap baited with excrement of lynx.

Hydrotaea cristata Malloch. Bethel (HCH), Birch Lake (HCH), Central (MTJ), Circle (HCH), Ladd Air Force Base (HCH); June–September; traps baited with beef liver, carrion and excrement.

Hydrotaea dentipes (Fabricius). Nome (HCH); 22 August; store window.

Hydrotaea houghi Malloch complex. Central (MTJ), Minchumina (MTJ), Ladd Air Force Base (MTJ); June; traps baited with beef liver, carrion and excrement.

Hydrotaea militaris Meigen. Birch Lake (HCH); 11 August; random collecting.

Hydrotaea occulata Meigen. Circle (HCH); 19 August; trap baited with entrails of a hare.

Hydrotaea pilipes Stein. Ladd Air Force Base (HCH); 28 July; trap baited with excrement of lynx.

Hydrotaea pilitibia Stein. Fort Yukon (HCH); 10 July; kitchen window.

Hydrotaea ringdahli Stein. Central (HCH), Minchumina (HCH); June; traps baited with carrion and human excrement.

Hydrotaea scambus (Zetterstedt). Fort Yukon (HCH), Tok Highway-Mile 23 (HCH); July–August; random collecting.

Hydrotaea unispinosa Stein. Ladd Air Force Base (MTJ); 11 June; trap baited with human excrement.

Hylemya acrostichalis Malloch. Central (HCH), Nome (HCH); June, August; traps baited with beef liver and carrion.

Hylemya albula (Fallén). Minchumina (HCH); 9 June; trap baited with human excrement.

Hylemya fabricii (Holmgren). Ladd Air Force Base (HCH), Nome (HCH); August–September; traps baited with beef liver and excrement of bear.

Hylemya hinei Malloch. Ladd Air Force Base (HCH); June; traps baited with beef liver and carrion.

Hylemya hucketti Ringdahl. Central (HCH), Ladd Air Force Base (HCH); June; traps baited with beef liver and carrion.

Hylemya lasciva (Zetterstedt). Central (HCH), Minchumina (HCH); June; traps baited with human excrement.

Hylemya octoguttata (Meigen). Circle (HCH), Circle Hot Springs (HCH), Galena (HCH), Ladd Air Force Base (HCH), Paxson (HCH); May–September; traps baited with beef liver, carrion and excrement.

Hylemya platura (Meigen). Ladd Air Force Base (HCH); May–September; traps baited with excrement.

Hylemya replicata Huckett. Minchumina (HCH); 9 June; trap baited with beef liver.

Hylemya sericea Malloch. Nome (HCH); 24 August; trap baited with beef liver.

Hylemya subnitida Malloch. Central (HCH); 22 June; trap baited with entrails of hare.

Hylemya variata (Fallén). Bethel (HCH); 3 September; trap baited with carrion.

Hypodermodes solitaria Knab. Minchumina (MTJ); 5 June; trap baited with human excrement.

Lasiops furcatus Stein. Nome (HCH); 23 August; trap baited with beef liver.

Limnophora uniseta Stein. Nome (HCH); 20 August; random collecting.

Lispe tentaculata (Degeer). Paxson (MTJ); 5 September 1952; garbage dump. The species is not usually associated with filth and its occurrence near the garbage dump was probably of no significance.

Morellia podagrica Loew. Central (HCH), Circle (HCH); June; store window and trap baited with carrion.

Muscina assimilis (Fallén). Central (MTJ), Circle (GDG), Circle Hot Springs (MTJ), Fort Yukon (GDG), Ladd Air Force Base (MTJ), Livengood (GDG), Minchumina (MTJ), Paxson (MTJ), Rapids (MTJ), Umiat (GDG); April–September; traps baited with beef liver, carrion and excrement; collected inside privies; reared from eggs deposited in waste pans under laboratory rat cages.

Muscina stabulans (Fallén). Ladd Air Force Base (MTJ); August–September; traps baited with carrion and excrement; collected indoors.

Mydaea obscurella Malloch. Central (MTJ), Circle Hot Springs (MTJ), Fairbanks (MTJ), Minchumina (MTJ), Paxson (MTJ); June–September; traps baited with human excrement and carrion.

Mydaea occidentalis Malloch. Ladd Air Force Base (MTJ); 8 July; trap baited with human excrement.

Mydaea orichalcea (Zetterstedt). Ladd Air Force Base (MTJ); 17 August; trap baited with feces of bear.

Mydaea persimilis Malloch. Central (MTJ), Circle Hot Springs (MTJ), Minchumina (MTJ); June–August; traps baited with carrion and excrement.

Myopina reflexa Robineau-Desvoidy. Minchumina (HCH); 4 June; trap baited with beef liver.

Myospila meditabunda (Fabricius). Central (MTJ), Circle (GDG), Ladd Air Force Base (MTJ), Minchumina (MTJ), Paxson (GDG), Umiat (MTJ); June–August; traps baited with beef liver, carrion and excrement.

Paregle mystacea (Coquillett). Circle Hot Springs (MTJ), Fort Yukon (MTJ), Ladd Air Force Base (MTJ), Minchumina (MTJ), Nome (MTJ), Paxson (MTJ), Umiat (MTJ); May–September; traps baited with beef liver, carrion and excrement.

Paregle radicum (Linnaeus). Ladd Air Force Base (MTJ), Umiat (MTJ); May–July; traps baited with excrement.

Pegomya caesia Stein. Nome (MTJ); August; trap baited with beef liver.

Pegomya incisiva Stein. Fort Yukon (HCH); 12 July; trap baited with entrails of hare.

Pegomya nigroscutellata (Stein). Central (HCH); 24 June; trap baited with human excrement.

Pegomya patellans (Pandellé). Central (HCH); Circle Hot Springs (HCH); June, August; traps baited with entrails of hare and with human excrement.

Pegomya pilosa Stein. Fairbanks (MTJ), Nome (MTJ); August–September; trap baited with excrement, random collecting.

Pegomya solitaria Stein. Circle (MTJ), Ladd Air Force Base (MTJ); August–September; traps baited with carrion and excrement.

Pegomya tarsata (van der Wulp). Along road from Paxson to Tangle Lakes (HCH); 7 September; random collecting.

Phaonia errans (Meigen). Minchumina (MTJ); 9 June; traps baited with carrion and excrement.

Pseudophaonia griseocaerulea Malloch. Minchumina (MTJ); 9 June; trap baited with human excrement.

Pyrellia cyanicolor (Zetterstedt). Central (GDG), Ladd Air Force Base (MTJ), Minchumina (MTJ), Paxson (MTJ), Rapids (MTJ); April–June; traps baited with carrion and excrement.

Xenomydaea buccata Malloch. Central (MTJ); June; traps baited with excrement and entrails of a hare.

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Fecundity and Cold Survival of the House Fly[1]

BERNARD GREENBERG[2]

This study concerns the effect of isolation on the fecundity of house flies, *Musca domestica* L., and contains observations on cold survival of maggots, pupae, and adults. The former study was undertaken, in part, to answer a need for a homozygous strain of flies—best accomplished through consecutive brother-sister matings over several generations. Though no difficulty was encountered in obtaining seven successive generations of normally ovipositing house flies, many early workers reported poor success with single pairs, so it was decided to study the problem further.

Hutchison (1916), using single pairs of house flies, obtained egg deposition in only 7 out of 30 pairs, with a maximum of 110 eggs in 2 batches. He attributes this inhibition of oviposition to a "psychological factor." These observations were later confirmed by Glaser (1923). Roubaud (1922) found that isolated females in small cages laid fewer eggs and died in 10 days or less; he cites Awati (1920) who studied *Musca nebulo* Fabr. and *M. angustifrons* Thoms. with similar results. Dunn (1923), Feldman-Muhsam (1944) and Hampton (1952), however, have reared pairs of house flies with good success.

MATERIALS AND METHODS.—A strain of *Musca domestica* L. collected in Lawrence, Kansas, was used for this work. Stock house flies were kept in 18″ by 18″ by 18″ cages. The house flies fed and oviposited satisfactorily on cellucotton moistened with a mixture of powdered milk and honey. Newly emerged adults were paired and placed in small conical screen cages (Fig. 1). The cone cage measures 11 cm. in height with a base diameter of 5 cm. and fits into a stender dish of comparable diameter. A cardboard collar is used to prevent intruding house flies from ovipositing on the interior of the dish, or the cone may simply be slipped over the dish. Paired and stock house flies were fed identically, the former being immobilized daily in a 7° C. cold room just long enough to substitute a fresh dish. Knipe & Frings (1953) have pointed out the possibility of a female ovipositing through a screen and dropping her eggs on the substrate which is beyond the reach of her ovipositor. In our experience, even when cone cages were placed in densely populated fly cages, no such adventitious depositions were encountered which might be mistakenly attributed to the single female within the cone. Perhaps if the flies in the large cage had not had suitable breeding material, this phenomenon would have been observed. Egg batches were found most often tucked away below the surface of the cellucotton in a fairly protected situation. Dishes were examined daily for eggs which were most readily recovered by teasing the cellucotton apart under water. Eggs were then placed on moist paper toweling in a petri dish to hatch.

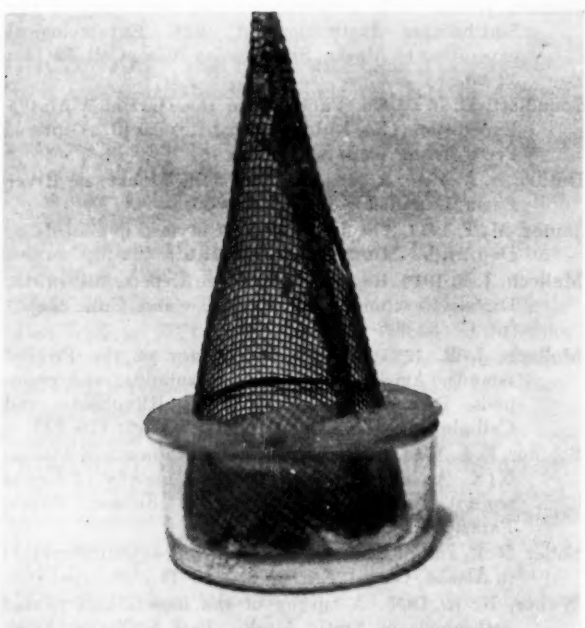

FIG. 1—Cone cage.

Cone cages were kept in two types of situations: 1. within the fly cages; 2. within the same room containing the fly cages. Throughout these experiments conducted over a period of a year, humidity was uncontrolled, with a probable range of 30 to 70 per cent, and room temperature was maintained near 25° C.

RESULTS.—A comparison of the fecundity of pairs of house flies kept under the two sets of conditions described above indicates a similar performance for the two groups (Table 1). Far from demonstrating an inhibiting effect due to isolation, the data show that one of the isolated pairs actually produced almost twice as many eggs as the most prolific control pair. If we omit the data for this unusual pair, the two sets of means show no significant differences, except possibly in the longevity of the male in the isolated group. In the majority of cases, the female outlived the male in both groups.

DISCUSSION.—There is a striking similarity between these data and those obtained by Hampton (1952). The fact that Hampton and the author used different strains of house flies under experimental conditions which must inevitably differ in a number of factors lends support to the results. Feldman-Muhsam (1944), working with the Levant fly, *Musca domestica vicina* (Macq.), calculated the average daily egg yield per female, disregarding the preoviposition period, as 30.6. In this study, it was found to be 37.1, again a fairly close correspondence.

Dunn's data (1923) indicate a rather extreme example of fertility. He reports as many as 14 to 17 batches of eggs were deposited by some females, and one individual

[1] Accepted for publication April 8, 1955. This work was conducted in the Entomology Department, University of Kansas, Lawrence, and is a portion of a doctoral thesis. The facilities of the Bacteriology Department were generously made available for this study. For their excellent criticism of the manuscript, the author is grateful to Dr. Charles D. Michener, Entomology Department, University of Kansas; Dr. Luther S. West, Biology Department, Northern Michigan College at Marquette; and Mr. Floyd A. Swink of this Department.

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Table 1.—Comparative fecundity of isolated and control flies.

Controls	Preoviposition Period (Days)	Number Egg Batches	Frequency (Longevity) (No. of Batches)	Total Eggs	Longevity (Days) Female	Male
1	4.0	4	6.0	265	24	12
2	4.0	9	4.1	891	37	40
3	4.0	—	—	—	—	—
10	3.0	11	2.2	772	24	17
11	2.5	11	2.3	821	25	24
12	2.5	7	3.1	772	22	—
15	4.0	8	2.9	837	23	27
16	4.0	9	2.0	768	18	16
Average	3.5	8.4	3.2	732	24.7	22.7
Isolated						
8	4.0	4	5.8	459	23	11
9	2.5	14	2.0	1688	28	24
13	2.5	8	3.3	891	26	22
14	3.0	11	2.4	647	26	20
17	3.0	10	2.7	914	27	12
Average	3.0	9.4	3.2	920	26	17.8

laid a total of 2,387 eggs in 21 batches. The selection of large females (about 8.5 mm. in length) would help to account for this phenomenon. Medium-sized house flies (about 7 mm. in length) usually lay batches containing less than 100 eggs. Though the number of batches produced during their life-time is comparable to that of large flies, the number of eggs per batch is dependent on the number of ovarioles, which, in turn, may be a function of the individual's size. Under favorable conditions, individuals were found to have fairly consistent maxima, whatever their size. Twenty-four hours is approximately the minimum time for the maturation and deposition of a batch of eggs, and the process can be repeated on 3 consecutive days.

Concerning the relationship of age to egg production, the data from 11 females have been analyzed in the following way. The adult life of the fly, excluding the preoviposition period, was divided into three equal periods. Since the average functional longevity was about 25 days, each period constitutes slightly more than 8 days. The number of eggs laid by each fly for each period was tallied and percentages obtained; averages for all the flies for each period were then computed. There was a decline in egg production from 43.4 per cent of the total during the first period, to 34.9 per cent and 21.7 per cent, during the second and final periods, respectively. Roubaud (1922) observed a decrease in egg laying during the second month among populations of house flies maintained in large cages. He ascribes this decrease and also the poor fecundity of flies in small cages to a restriction of flight; in the large cages, the increased fraying and tearing of the wings gradually reduce the ability to fly. This hardly suffices as an explanation for our experiments, where the cone cages reduce flying to a minimum from the beginning, without any apparent reduction in fecundity.

Since the visual presence of other house flies seems to have no effect on the fecundity of enclosed pairs of flies, it was thought that possibly an olfactory stimulus, originating with the caged flies and permeating the room, might affect egg laying. Some preliminary experiments were performed in which pairs were kept in rooms where no other flies were present, while controls were kept in the fly room, and in the cages themselves. The average preoviposition period for 5 completely isolated pairs was 5.9 days, compared with 3.7 days for 3 controls, and there was some indication that completely isolated flies laid fewer eggs, but a quantitative comparison cannot be made at this time.

Some indication of the extent of variation in reported fecundity data is presented in table 4.

COLD SURVIVAL.—Several studies have been made on the ability of the various stages of the house fly to survive cold, and the subject is well reviewed by West (1951) (see also Hewitt 1914). Wigglesworth (1953) discusses the effect of pre-conditioning on the temperature response of various species of insects. Table 2 summarizes the results of several experiments wherein larvae reared at 21° C., at room temperature (25° C. to 28° C.), and at 36° C. were subsequently exposed to prolonged cooling and then returned to room temperature to complete their development. The eggs used were from pools obtained from many females, and the C.S.M.A. breeding material was uniformly prepared for all groups (Greenberg 1954). Maggots reared at 21° C. lagged in development about 7 days behind the 36° C. maggots. When full grown, the maggots were counted, returned to the medium, and placed at 7° C. for 6 days. At the end of this time, survivors were counted and returned to room temperature to complete their development. Ordinarily, when reared at a uniform temperature of 36° C., 90 to 100 per cent of mature third instars will pupate. Maggots reared at 21° C. show no greater ability to survive prolonged cooling than maggots reared at room temperature, but those reared at 36° C. have markedly reduced ability to survive. The physiological basis for this phenomenon of pre-conditioning remains obscure , but from a behavioral point of view, it may simply be that the conditioned larvae, having some mobility at the lower temperature, are able to feed and thus remain alive. Eighty-four per cent of 3rd instar larvae reared at 36° C. and then kept in moist sawdust without food, survived 7° C. for 2 days, but after 5 days only 12 per cent were still alive. In nature, the advent of cool weather conditions the cold survival of the larvae and may aid them for a time to avoid freezing temperatures by moving slowly down into the substrate. Mature maggots uncovered in the fall when the soil temperature was 8° C. immediately began burrowing into the soil. Whether this can lead to the survival of maggots through the winter is questionable, but it does emphasize the necessity for considering the factor of pre-adaptation in laboratory studies on temperature survival. Zhovtyi

Table 2.—Survival of variously conditioned larvae exposed to 7° C. for 6 days.

Rearing Temp. (° C.)	Number of Survivors	Per Cent Survivors	Per Cent of Survivors Pupated
36	12/39	30.8	8.3
36	9/137	6.6	0.0
36[a]	20/31	64.5	0.0
25 to 28	299/314	95.2	90.6
21	19/19	100.0	78.9
21	271/307	88.3	45.7

[a] Reared at 25° to 28° C. and then placed at 36° C. for 48 hours before being put into cold room.

Table 3.—Emergence of adults from pupae exposed to 7° C. for various periods.

DAYS AT 7° C.	NUMBER OF SURVIVORS	PER CENT SURVIVORS
16	80/300	26.7
19	13/50	26.0
31	3/55	5.5
38	0/30	0.0
63	0/141	0.0
Control	88/100	88.0

(1951) studied hibernation of the house fly in Siberia, in a region where the frost period (temperatures below 10° C.) is 245 to 265 days. He found larvae hibernating in the breeding material and up to 1.5 meters away from it, at a depth in the soil of 20 cm. He reports that the minimum winter temperature of the soil containing the larvae and pupae does not reach their average freezing temperature (−12° C.).

Prolonged cooling (at 7° C.) of pupae, previously reared at 25° C. to 28° C., resulted in considerable mortality before the 16th day and no survivors after the 38th day (Table 3). Larvae were reared in a jar, 6 inches in diameter and 6 inches high, to supply sufficient numbers of pupae; when the majority of the larvae pupated, 100 pupae were removed and the jar was placed in the cold room. The 100 pupae were kept at room temperature on moist cellucotton in a cone cage and constituted the control. Test pupae received similar treatment after their exposure. Water was added to the medium from time to time to prevent desiccation. From the results, it does not appear that pupae are particularly resistant to prolonged cooling.

The question of how house flies survive the cold season still needs to be answered. Matthysse (1945) has found good evidence for continuous breeding in large dairy barns during the winter. Whether this is the primary or sole mode of survival, or whether alternatives exist, awaits more extended field studies.

To test their ability to survive low temperatures, it was decided to keep adults outdoors under approximately natural conditions. Exposure to low temperatures in laboratory experiments is usually far more sudden than it is in nature. A conical cage containing 30 recently emerged house flies was placed outdoors on November 9, 1953, and maintained through December 15. The flies were fed in the usual manner. During this period there were many days when the minimum temperature was at or below freezing. By December 14, 17 flies were dead. There followed a period of 44 hours during which the average hourly temperature was −5.0° C., with a maximum of −1.2° C. and a minimum of −8.5° C. This minimum was recorded for two alternate hours with an intervening temperature of −7.9° C. Seven of 13 flies survived this exposure. The survivors were brought into the laboratory and during the first few hours their movements were poorly coordinated, walking with difficulty and unable to fly. Two days later, however, oviposition occurred. Another cone cage containing 20 house flies, put outdoors on December 6, had only one survivor during

Table 4.—Summary of house fly fecundity data from various authors.

AUTHOR	PREOVIPOSITION PERIOD (DAYS)	NO. OF BATCHES OF EGGS	TOTAL NO. OF EGGS	LONGEVITY AT SUMMER TEMPERATURE (DAYS)	FOOD OF ADULTS
Hewitt	14 to 18	4 to 6	480 to 720	49 (max.)	—
Bishopp *et al.*	4 to 9	2	—	14 to 28	manure[a]
Hutchison	2.5 (min.) 11 (mean) 9[a]	1 or 2[a]	25 to 110[a]	19+ (mean) 13 (♂) (mean)[a] 15 (♀) (mean)[a]	banana, water and manure; manure & bran[a]
Roubaud	6 to 10	—	600	66 (max.)	sweetened milk
Dunn[a]	2¼ (min.)	14 to 17 21 (max.)	2,387 (max.)	33	milk and horse manure
Glaser	11 to 24 15 (mean)	1 or 2	—	20+ (mean)	combinations of carbohydrate and protein
Feldman-Muhsam[a]	4 (min.) 7 (mean)	2.6 (mean) 9 (max.)	267 (mean) 500 (max. and theoretical)	21	diluted milk
West	4 to 8 (after copulation)	4 to 6	480 to 720	14 to 21	—
Hampton[a]	4.5 (mean)	6 to 12 8 (mean)	577 to 1278 805 (mean)	18 to 36 26 (mean)	diluted milk
Greenberg[a] (this study)	3.3 (mean)	8.9 (mean)	826 (mean)	25.3 (♀) (mean) 20.3 (♂) (mean)	milk and honey

[a] Based on single pairs.

the same test period. No significant differences were observed in the cold hardiness of the sexes in this as well as other unreported experiments.

On the basis of these data, it is not possible to conclude that the adult is able to survive the winter in this area. The release of tagged, field-caught adults in the fall into a variety of feeding and breeding locations, such as barns, houses, animal enclosures, and garbage dumps, with attempts to capture them throughout the winter might yield pertinent data concerning adult ability to overwinter. Where there are few or no adults observed during the winter, an effort should be made to recover immature stages from known breeding grounds.

SUMMARY.—Paired house flies, visually isolated from all other house flies, compared well regarding fecundity and longevity with controls housed with caged populations. A general decline in egg production with age was noted among paired house flies.

Larvae reared to the third instar at 36° C. and then exposed to 7° C. for 6 days suffered a significantly higher mortality than those previously reared at 25 to 28° C. or at 21° C. and then exposed. Mortality in the 36° C. group may be the result of starvation due to immobility.

Prolonged cooling (at 7° C.) of pupae, previously reared at 25 to 28° C., resulted in considerable mortality before the 16th day and no survivors after the 38th day.

Of 13 adults remaining from a larger number maintained outdoors during the late fall, 7 survived a period of 44 hours when the maximum temperature was −1.2° C. and the minimum was −8.5° C. Oviposition occurred 2 days after return to room temperature.

A tabular summary of house fly fecundity data from various authors is included.

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Emergency Measures Directed Against Mexican Fruit Fly Threat to California[1]

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The recent appearance of the Mexican fruit fly, *Anastrepha ludens* (Loew), in Baja California just below the State border has presented a situation of serious concern to California fruit growers not greatly dissimilar to that which has confronted growers in the Rio Grande Valley of Texas for many years.

Each year the grapefruit plantings in southern Texas have been exposed to infestation by flies moving northward from a heavy native population in nearby northeastern Mexico. If the infestation in Baja California is allowed to persist, similar northward movement of flies would present a continuous source of infestation of California fruits. Here, however, the similarity in situations ceases.

HOST CONTINUITY DETERMINES PEST IMPORTANCE.—In Texas, grapefruit represents the only economic host involved. Practically all others, which were never present in any great abundance, were removed during the eradication effort conducted when the fly first made its appearance in their orchards in 1927. The period of susceptibility to attack of this single host is relatively short being roughly from November through May. In the absence of any continuity of hosts, local survival of the fly is precluded and reinfestation each year must originate with natural spread from the reservoir of flies in Mexico. Fortunately, it is possible for the growers to move most of the crop before seasonal infestation develops under these conditions. The relatively small balance moves under approved supervised, certified vapor heat treatment.

[1] Presented at the Second Annual Meeting of the Entomological Society of America held in Houston, Texas, December 6–9, 1954. Accepted for publication May 4, 1955.

The situation presented in California is entirely different. While not as preferred a host as grapefruit, oranges present a continuity of occurrence that more than offsets that difference. These occur first in the form of Navels from November to May followed by Valencias from May to November. They are available in considerable contiguous acreage throughout the southern part of the state. In addition, practically all other types of recorded hosts occur in this same area in appreciable through scattered acreage and collectively further assure a continuity of susceptible host fruits that would not only permit survival of the fly within the area but also rapid seasonal increase to damaging numbers.

HOST TOLERANCE TO QUARANTINE TREATMENTS.—Unfortunately, oranges are not fully tolerant, and other hosts not at all, to the disinfection measures which have been so successfully used in Texas where grapefruit is concerned. Under established infestation all recorded hosts would be made subject to some form of approved treatment as a condition of movement to clean areas. Each season early infestation and buildup would be possible from any existing local population of flies. On the other hand the application of costly eradication measures, no matter how successful, would be quickly nullified by the continued influx of flies from below the border.

Obviously, therefore, the current problem, from the standpoint of California, lies in the elimination of existing infestations below the Border. But here again such effort would be wasted unless effective means of closing all avenues of early re-introduction can be worked out. Such re-introduction is restricted to "carry-in" of infested fruits, as the area is geographically isolated against natural spread from the infested area in Mexico. It is entirely possible, as claimed by some, that the small number of flies now being trapped in Baja California originate with heavily infested fruit which found its way into the area from Mexico during past months in spite of established quarantine regulations. However, there would also seem to be ample evidence that there is now a general though obviously very light established infestation in the area.

QUARANTINE SAFEGUARDS.—The first step taken by the Mexican agricultural officials, working in close cooperation with representatives of the U. S. Department of Agriculture, has been to provide fumigation facilities that will assure the officially supervised disinfection of all commerical shipments of host fruits moving into Baja California from Mexico proper, furnished at no cost to the shippers. In addition the same agencies have tightened up on all other possible avenues of entry of such fruit. It is hoped that these combined measures will satisfactorily meet this problem.

ERADICATION MEASURES IN BAJA CALIFORNIA.—Concurrently, with the approval and assistance of the Mexican officials, the U. S. Department of Agriculture is making a concerted effort to eradicate existing infestation in Baja California by placing all host trees under treatment in the Tijuana area, as well as those lying within 1 mile of the property on which a single fly has been trapped at Mexicali and at Ensenada. While individual flies have continued to be trapped in the Tijuana area as late as November 23 in 1954, and in one instance three puparia sifted from soil on one of the properties on which adults have been trapped repeatedly, no larval infestation in fruit has ever been found. This indicates the nature and degree of infestation as known up to the present writing. A full evaluation of the results of the current measures will not be possible until the following spring, at the earliest. If no further adults are trapped then, it will at least indicate a favorable trend in the effort.

Many of the properties on which adult flies have been trapped in the Tijuana area have been located just below the International Border and in the center of a contiguous agricultural area extending well up into San Diego County in California. However, for obvious legal reasons, it was not possible for California to immediately undertake any *mandatory* protective measures with respect to host properties on the California side of the line, regardless of their immediate proximity to properties below the border on which flies have been taken.

PROTECTIVE BARRIER ESTABLISHED BY CALIFORNIA.—Nevertheless, the California Department of Agriculture, with federal and border-county assistance and the full cooperation of the property owners concerned, has undertaken the establishment and maintenance of a protective barrier along the entire southern border of the state. This barrier is designed to attract or intercept, and eliminate, any flies that normally might be expected to be moving northward from the infested area below the border.

The measures used involve the frequent application of an attractive poison-bait spray, having a high residual value, to all host trees lying within 5 miles of the border. The materials used are the same as those being applied in the eradication operations below the border. A formulation composed of 4 pounds tartar emetic and 20 pounds of cane sugar in 100 gallons of water is being applied as a mist spray to the undersides of the foliage within the host tree at the rate of approximately 1 quart to each host. This formulation has recently proven equally effective against the species of fruit flies under study in the Hawaiian Islands. It was developed by Dr. A. C. Baker, formerly in charge of the federal Mexican fruit fly research laboratory in Mexico City. Recent studies at that laboratory indicate that where *ludens* is concerned, the addition of 1 pound of protein hydrolysate to each 100 gallons of spray may materially increase its attractiveness.

Based on the effective residual limits of the tartar emetic, spray applications are being made every 3 weeks. This procedure is being conducted on a year round basis as there would appear to be no period of extended inactivity in any stage where *ludens* is concerned.

The carrying out of this program is proving a tremendous public relations job as over 4,000 property owners are involved. Ninety per cent of the hosts treated occur as yard trees on residential properties, there being a minimum of commercial host acreage in this particular area along the border. These owners have little interest in the problem and are greatly inconvenienced by the operations. In addition, it is not possible to show them the presence of the insect against which the measures are being directed. Nevertheless, at the end of the thirteenth application they are still extending their complete cooperation. There would seem to be no way at this time of accurately determining whether this action is giving

the protection desired. If the conclusions arrived at hold true with respect to the source of seasonal infestation in Texas, *ludens* has the ability to travel more than 100 miles in a single season. However, the California Department is banking on the assumption that such movement is not made in one or even in several long jumps but rather in a series of very short hops. On the latter basis it would seem reasonable to expect that any northward spread of flies would be intercepted by the barrier as planned. It seems certain that if intercepted they would be eliminated through feeding on the attractive poison bait proved.

SIGNIFICANCE OF SINGLE FLY TRAPPED.—To date the "catch" in California has been restricted to a single adult fly taken in a trap located on a property well within the treatment barrier in San Diego County. This fly might reasonably be assumed to be a migrant. On the other hand there is so much at stake from the standpoint of the fruit growers that the Department deems it wise and has elected to consider that it might have stemmed from a local infestation and therefore merit immediate application of eradicative measures.

ERADICATION MEASURES APPLIED.—In addition to the spray program previously outlined which fortunately has included all host trees within 1 mile of this finding, other measures being applied have included the addition of 4 pounds of isodrin per acre to the upper 2 inches of soil under all host trees, for such control value as it may have against mature larvae entering the soil for pupation, the resulting puparium, and/or the subsequently emerging adult; also the daily examination and destruction of all prematurely colored or fallen fruit which might be suspected of carrying infestation and otherwise might permit the escape of mature larvae into the soil for pupation. As a further measure, one or more traps have been placed on each host tree in this area for such value as they may have in actually attracting and eliminating emerging adults before they became sexually mature and have the opportunity to oviposit.

While those who should know feel that there is every possibility of *ludens* surviving and at least on occasion causing economic damage in Southern California, there is no positive information supporting that belief. To the extent that it can be determined by such means, the climates of San Diego, El Centro and Oceanside are now being simulated in bio-climatic chambers located at Brownsville, Texas and their effect on *ludens* observed. Other critical localities will be similarly studied as facilities permit.

A Surface Aliquot Masking Technique for the Bioassay of Lindane[1]

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Recently Queen (1953) reported on the contamination of foodstuffs, packaging materials and building surfaces with lindane originating from a type of commercial thermogenerator in common use.

While the chemical method (Schechter & Hornstein 1952, Hornstein & Sullivan 1953) was found readily applicable to foodstuffs, its extension to building surfaces posed several difficulties: solvent extraction (1) tended to modify or destroy the surface; (2) removed lindane deposited below the surface; (3) posed problems of interference with the chemical method particularly in the case of painted surfaces.

An adaptation of a sensitive bioassay method (Laug 1946) using the house fly proved to be accurate and sufficiently rapid to evaluate surface contamination with lindane. However, the sensitivity of house flies to lindane limited the assay range from 0.5 to 2.0 micrograms. The morality within this interval was between 20 and 80 per cent. Mortalities beyond these limits generally tended to give less reliable results and at the extremes could not be assayed.

Ordinarily, excessively high concentrations of lindane in solution are surmounted by the selection of the proper aliquots of solution. Therefore, it seemed reasonable to speculate that excessive concentrations of lindane deposited on a surface could be assayed by taking an aliquot of the surface area.

METHOD.—To test the validity of the surface aliquot procedure, a masking technique with a material impervious to lindane was used. Scotch Tape proved most convenient, although it is advisable to test each batch for absolute impermiability. This may be accomplished by totally masking a surface containing a high concentration of lindane. Except for several minor modifications, the principle of the method and the general procedures followed are those developed in this laboratory (Laug 1946, 1948). The strain of house fly employed for the tests originated from Beltsville stock and has been continuously reared in our laboratories for a number of years. The insects were used only within the period of 1 to 5 days following emergence. They were stored in large wire cones and fed daily with sweetened diluted milk, except while under assay. The insects were transferred under CO_2 anesthesia. A constant weight of 1.3 gms. i.e., about 75 flies, was placed in contact with each surface to be assayed. The maximum surface area was 74 $(cm.)^2$ as determined by a 9.7 cm. diameter glass crystallizing dish having a capacity of 370 $(cm.)^3$. The standards were prepared by evaporating petroleum ether solutions of lindane from the flat glass floor of the dish with an added 5 mg. oleic acid to prevent loss of the insecticide through volatilization. To further decrease losses during the process of

[1] Accepted for publication April 8, 1955.

Table 1.—Analyses of filter paper surfaces for lindane.

Area Exposed to Flies (Cm.)²	Per Cent Mortality	Calculated Surface Concentration of Lindane Mmg./(Cm.)²
Paper treated with benzene solution of lindane 160 mmg./ml.		
4.8	100	
4.0	100	
3.8	100	
2.8	91	0.58
2.1	85	0.66
2.1	91	0.78
2.0	89	0.79
2.0	71	0.54
1.0	21	0.51
1.0	20	0.50
		Average 0.62[a] mmg./(cm.)²
Paper treated with benzene solution of lindane 80 mmg./ml.		
4.0	69	0.26
4.0	80	0.31
3.8	75	0.30
3.3	37	0.20
2.8	50	0.28
2.8	49	0.28
2.4	57	0.36
2.3	51	0.35
2.3	37	0.23
1.0	0	Average 0.28 mmg./(cm.)²
Control[b]	0	

[a] 0.52 mmg./(cm.)² for those samples in which the mortality was between 20 and 80 per cent.
[b] Completely masked area which contained 0.28 mmg. lindane/(cm.)².

evaporation the crystallizing dish was covered with a watch glass so that only a small narrow orifice remained. During the assay the flies were confined under the same watch glass. The relationship of the crystallizing dish with respect to the surface exposed to the insects was of necessity the same for both the unknowns and the standards. No oleic acid was added to the unknowns.

The insects were allowed to remain in contact with the surface for a period of 18 to 20 hours. At the end of this time the living and dead were counted and the regression line relating mortality to the dose of the standards plotted on log-probit paper. The concentration of lindane on the treated samples was determined by reference to the regression line plotted with each assay. All assays were run in an air-conditioned room maintained at 22 to 24° C.

Results.—Half a milliliter of a solution containing 3.2 mmg. lindane and 5 mg. oleic acid per milliliter were placed on a series of glass plates. After the ether solvent evaporated, the residues appeared to be evenly distributed in a circular area. Plate 1 which contained 1.6 mmg. was left unmasked (total area 74 sq. cm.); plate 2 was half masked, plate 3 was three-quarters masked; plate 4 was seven-eighths masked; and plate 5 was completely masked and served as a control.

The amounts of insecticide available to the flies were 1.6, 0.8, 0.4, 0.2, and 0.0 mmg. of lindane. The percentage mortalities after 20 hours were 94, 55, 17, 1, and 0, respectively. When these data were plotted in a probit-log dose form, a straight line resulted, Repeated assays, using the described technique, resulted in the conclusion that the masking of portions of the total contaminated area is equivalent to taking aliquots of the dose. In order to determine whether or not the relationship held true for extremely small areas, flies were exposed to highly contaminated surfaces. The insecticide was uniformly distributed on filter papers by immersing the papers in benzene solutions of lindane (160 mmg./ml. and 80 mmg./ml.), and then allowing the papers to air dry for 30 minutes. The papers were then cut into strips, with the cut edges masked with Scotch cellophane Tape. The exposed areas ranged from 1 to 4 sq. cm. That the oleic acid does not significantly affect the slope of LD_{50} of the dosage response curve was established by assaying lindane on glass surfaces with and without the presence of oleic acid. The loss of lindane from the surfaces free of oleic acid was minimized by carefully evaporating the solvent at zero degrees Centigrade.

It is apparent from the data presented in table 1 that, within the limits of biological assay, the calculated surface concentration of lindane is reasonably accurate for areas as small as 1 sq. cm.

Examples of the application of this method are shown in table 2. Kraft paper, painted surfaces, cellophane, linoleum, and wax paper were exposed to lindane vapors under conditions that might obtain in practice. Repetition of individual tests show that satisfactory check analyses

Table 2.—Analyses of a number of surfaces exposed to vaporized lindane under a variety of test conditions.

Test No.	Surface	Area Analyzed (Cm.)²	Concentration of Lindane Mmg./(Cm.)²
1	Kraft paper	21	0.02
		34	0.01
		61	0.01
2	Kraft paper	7.7	0.10
		13	0.08
3	Painted surface	3.8	0.10
		6.2	0.10
4	Painted surface	1.4	0.75
		3.6	0.56
5	Cellophane	6.0	0.07
		12	0.06
6	Cellophane	2.9	0.28
		2.1	0.50
7	Linoleum	9.0	0.05
		13	0.06
8	Linoleum	0.92	0.94
		2.8	0.77
9	Linoleum	0.63	1.1
		1.4	0.70
10	Wax paper	31	0.03
		49	0.03
11	Wax paper	14	0.08
		23	0.06
12	Wax paper	2.1	0.34
		2.9	0.30

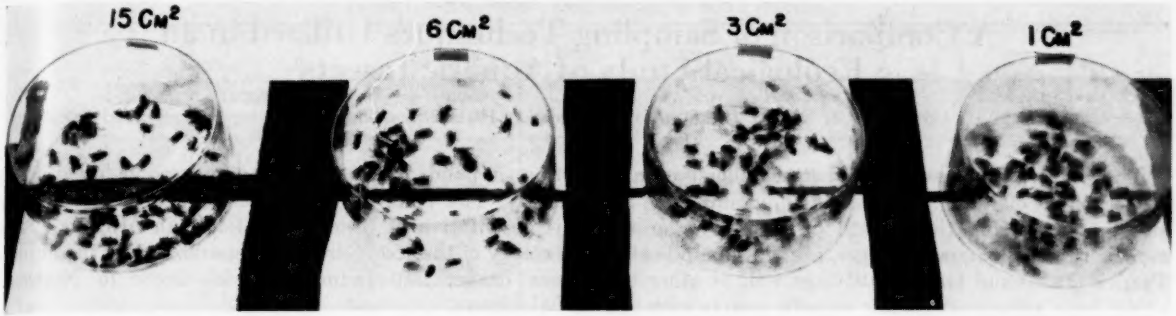

FIG. 1.—A simulated assay demonstrating the surface aliquot masking technique for the bioassay of lindane.

may be obtained over a 3-fold range of surface exposure.

Table 3 shows the reproducibility of the bioassay. All the samples and the reduplications were exposed (except for location in the room) and assayed under identical conditions. It is to be noted that some of the paper surfaces were either absolutely or partially protected from fall out of particulate matter. It is obvious that the same order of concentrations obtains in all situations. From this it can be concluded that under these conditions dispersion of lindane occurs via the gas phase.

In figure 1 a photograph of a simulated assay is presented. To contrast the dark contaminated area, white adhesive tape instead of Scotch Cellophane Tape was used. Cross strips of masking material, as in the case of the one and three square centimeter exposures, were used to further reduce the contaminated areas. The slow photographic exposure time (2 seconds) illustrates by its blurred appearance that the flies in contact with the one square centimeter of contaminated surface were alive and moving. The improvement in clarity of detail as the contaminated area is increased is evidence of augmented fly mortality.

Although the surface aliquot-masking technique has been explored only with lindane, there is no reason to believe that this technique would not be applicable to the biological assay of surfaces contaminated with other residual contact insecticides.

Table 3.—Analyses of kraft paper surfaces exposed in a closed room in which a lindane thermogenerator was in operation.

SURFACES OF A 4-INCH CUBE	LINDANE MMG./(CM.)²
Top (horizontal)	0.06, 0.07, 0.05
Under Side (horizontal)	0.06, 0.06, 0.04
Side (vertical)	0.09
Side (vertical)	0.08
Side (vertical)	0.05
Side (vertical)	0.05
Protected surfaces[a]	
1	0.08
2	0.05
3	0.06
4	0.06
Randomly distributed vertical and horizontal surfaces[b]	
1	0.04
2	0.07, 0.06
3	0.05, 0.04
4	0.08
5	0.05

[a] Kraft paper squares were laid on a shelf approximately 2 feet below a table top. In this position the surfaces were partially protected from direct "fall out" of particulate matter.

[b] Kraft paper squares were placed over various wall and floor areas with position 3 being on the floor directly below the thermogenerator.

SUMMARY.—A method for biologically assaying surfaces highly contaminated with lindane is presented. Mortality of flies is limited by securing an aliquot of the surface area. An aliquot of a surface is prepared by masking the remaining portion of the experimental area. The method is based upon the principle that, within the limits of the assay, a quantity of insecticide distributed over a small area will result in the same percentage mortality to flies as the identical quantity of insecticide spread over a larger area.

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A Comparison of Sampling Techniques Utilized in an Ecological Study of Aquatic Insects[1]

GORDON GUYER[2] and RAY HUTSON[3]

The increasing necessity for a better understanding of the problems of water pollution has pinpointed the possibility of utilizing the growth of aquatic organisms, especially certain aquatic midges, as pollution indicators. Patrick (1950) and Gaufin (1952) as well as other biologists have associated specific aquatic insects with various biological conditions in polluted lakes and streams. It is obvious that the usefulness of midge abundance and identification as a tool for use in the study of pollution will be directly proportional to the quantitative and qualitative accuracy of the sampling methods employed. Since specific indentifications can be made accurately on most of the adult aquatic insects, it appears that adult trapping devices would be applicable for such work. This study was undertaken to provide information concerning the effectiveness of adult insect-trapping devices. Various techniques for sampling adult insects were compared with the conventional bottom deposit sampling for larvae. In comparing sampling techniques the species composition, numerical distribution and seasonal variations of the aquatic fauna were studied.

In the past aquatic invertebrates have been sampled quantitatively and qualitatively either by the use of various bottom deposit samplers or by different adult sampling devices. Most of the sampling devices have been built for the purpose of investigating the organisms inhabiting a lotic environment. The bottom deposit samplers have included such devices as the square-foot trap described by Needham (1928), the dredges used by Petersen (1911) and Ekman (1911) and the collapsible 1-square-foot sampler employed by Surber (1936) in his study of stream bottom fauna-production. Needham (1908) in his investigation of stream insects at Old Forge, New York, was the first to use the tent trap method for collecting adult insects. Ide (1940) and Sprules (1947) both used a modification of the tent trap described by Needham in their investigations of the insect fauna of Canadian streams.

Adamstone & Harkness (1925) used the tent trap in the study of emerging insects from lakes. In Russian lakes, Grandilewskaja-Decksbach (1935) and Borutzky (1939) used metal funnel traps to study midge emergence. Brundin (1949) used a funnel trap made of metal netting in his investigation of the oligotrophic lakes of southern Sweden. Miller (1941) used a floating tent trap to study the ecology of the family Tendipedidae in Costello Lake, Ontario. The tent trap technique was also employed by Scott & Opdyke (1941) in their investigation of emerging insects from Winona Lake, Indiana. Macan (1949) found a floating tent trap useful in his ecological study of Three Dubs Tarn.

INSECT SAMPLING.—This investigation was conducted at two locations in the lower peninsula of Michigan. The 1952 studies were carried on at the Michigan State University Lake City Experiment Station in Missaukee County. The 1953 studies were located at the W. K. Kellog Forest in Kalamazoo County. At the Lake City Station six ponds and a reservoir area were included in the study. The Lake City and Kellogg Forest ponds were representative of farm ponds found in Michigan. The ecology of the reservoir was comparable with the numerous beaver impoundments which occur in Northern Michigan.

Two general sampling devices were employed to obtain the samples of adult insects. The first was a modification of an inverted metal funnel structure used by Brundin (1949) in his study of the fauna of Swedish mountain lakes. Two sizes of funnel traps were used; one which sampled a 1-square-yard area, the other ½-square-yard. Funnel traps were placed both on and suspended above the pond bottom. The traps were built of sheet metal and were arranged so that a two-quart jar could be fastened to the top. The second adult sampling device was a floating tent trap, similar to the one used by Macan (1949) in his survey of a moorland fishpond. The tent itself consisted of a wooden frame which covered a ½-square-yard area. The sides were covered with cotton cloth and the top with a transparent plastic hardware cloth.

All of the quantitative bottom deposit samples were taken with a 36-square-inch Ekman dredge. Bottom deposit samples were taken at weekly intervals at the Lake City ponds and biweekly periods at the Kellogg Forest ponds. In order that the bottom deposit samples from the Lake City ponds would be randomized as much as possible each pond was divided into quadrants. Samples were taken from the quadrants according to a randomized schedule decided on prior to the beginning of the study. This same procedure was followed in sampling the adult insects from the Lake City ponds. In the Lake City reservoir and the Kellogg Forest ponds definite stations were established and both the adult and immature samples were taken at the designated stations. In the laboratory a modification of the flotation method described by Welch (1948) was employed for separating the organisms from the debris.

INSECTS COLLECTED.—A total of 626 adult insect collections were taken from the Lake City reservoir and ponds and the Kellogg Forest ponds during 1952 and 1953. From these 626 adult samples there were 10,409 insects removed and classified. Table 1 gives the numerical distribution of the various taxonomic groups identified.

There were 338 bottom deposit collections taken from the Lake City ponds and reservoir and the Kellogg Forest ponds during 1952 and 1953. The 338 Ekman samples produced 14,343 immature insects which were more than 5 millimeters in length (Table 2). Since the sampling techniques followed did not accurately sample

PAID PAPER
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Table 1.—Numerical Distribution of adult insects.

POND AND STATION	TRIBE TENDIPEDINI	TRIBE CALOPSECTRINI	SUBFAMILY PELOPIINAE	SUBFAMILY CHAOBORINAE	SUBFAMILY HYDROBAENINAE	FAMILY HELEIDAE	ORDER TRICHOPTERA	ORDER EPHEMEROPTERA	MISCELLANEOUS INSECTS
Lake City									
A[a]	161	268	84	1	13	4	1	0	2
B[a]	249	623	73	7	2	8	0	2	2
B[c]	55	124	14	1	3	1	0	0	0
B[c] (suspended)	70	198	20	3	2	1	2	2	0
B[b]	70	286	64	6	12	53	4	0	0
C[a]	184	10	9	39	0	1	0	0	0
D[a]	1362	166	82	1572	3	0	0	2	1
E[a]	268	562	159	0	56	15	3	12	0
F[a]	159	1014	155	0	38	4	2	9	1
Lake City Reservoir									
a[c]	40	83	9	1	0	1	2	1	0
a[c]	59	331	74	2	15	6	4	2	0
b[c]	13	48	8	1	2	1	1	1	0
c[c]	12	41	9	1	13	1	1	1	1
Kellogg Forest									
Pond 1[a]	4	0	134	0	0	7	0	0	0
Pond 2[a] St. I	154	18	10	17	0	0	0	2	0
Pond 2[a] St. II	206	167	37	2	0	3	0	3	0
Pond 2[a] St. III	21	2	0	3	2	1	0	2	0
Pond 2[b] St. III	94	1	12	21	1	0	0	5	0
Pond 2[c] St. IV	82	10	9	0	7	3	0	10	5
Pond 2[c] St. V	171	7	3	1	0	2	0	2	4
Total	3434	3959	965	1678	169	112	20	56	16

[a] Samples taken with the 1-square-yard funnel trap.
[b] Samples taken with the ½-square-yard tent trap.
[c] Samples taken with the ½-square-yard funnel trap.

the smaller organisms only larvae over 5 millimeters were included in the quantitative calculations. There were five orders of insects represented in the bottom deposit samples. These five orders were Diptera, Ephemeroptera, Odonata, Coleoptera, and Hemiptera. The orders Coleoptera and Hemiptera were represented by so few specimens that they will not be considered numerically.

In certain taxonomic groups the percentage distribution of adults as determined by traps was consistently higher than for the immature forms as determined by benthic sampling and in others, the opposite condition occurred. This relationship was especially evident in the order Ephemeroptera where the immature samples always contained a higher percentage of mayflies than the adult samples. It was apparent from observations made of the mayflies emerging into the adult traps, that the mayflies did not emerge from their nymphal skin and pass through the subimago stage as readily in the traps as under natural conditions. The phantom-midges of the subfamily Chaoborinae were consistently more numerous in the adult samples than in the immature samples. The larval forms of the subfamily Chaoborinae appeared to be distributed in discontinuous colonies. In the subfamily Pelopiinae the percentage distribution of adults was always greater than the larvae. One explanation for this is the fact that *Procladius bellus* (Loew), a species very numerous in the adult samples, is a small one and many of the immature larvae passed through the sorting screens.

Table 2.—Numerical distribution of the immature[a] insects.

POND AND STATION	TRIBE TENDIPEDINI	SUBFAMILY PELOPIINAE	SUBFAMILY CHAOBORINAE	FAMILY HELEIDAE	ORDER EPHEMEROPTERA	SUBORDER ANISOPTERA	SUBORDER ZYGOPTERA
Lake City							
A	144	28	4	13	15	9	0
B	149	49	8	25	3	2	0
C	590	0	17	4	0	5	0
D	1,146	4	1124	9	13	4	0
E	67	81	0	7	193	47	5
F	36	58	2	27	145	54	1
Lake City Reservoir							
a	62	24	4	53	11	2	0
b	403	25	0	12	4	4	2
c	210	42	0	1	34	9	3
Kellogg Forest							
Pond 1	100	169	0	93	0	0	0
Pond 2, St. I	2,585	97	6	8	53	13	6
Pond 2, St. II	3,183	72	10	32	159	25	40
Pond 2, St. III	2,193	425	24	45	10	1	1
Total	10,868	1074	1199	329	640	175	58

[a] This table includes all larvae over 5 millimeters in length.

The seasonal distribution of the adult and immature forms of the various taxonomic groups was studied both qualitatively and quantitatively to compare the fluctuations which existed in the insect population using both adult and larval trapping devices. The data indicated that the emergence patterns of individual species as well as for the tribe Tendipedini as a whole, could be predicted equally well by the use of either the immature or adult samples. This was possible only when the immature forms were sampled to the same degree as were the adults. When the population is composed of small species the screens and techniques used in sampling the immature forms must be adjusted accordingly. In the Kellogg Forest pond where the population was composed primarily of

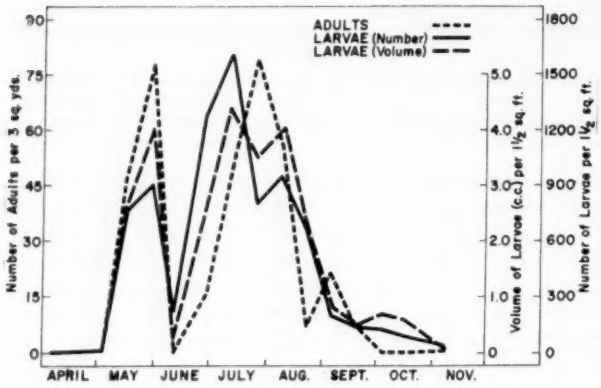

FIG. 1.—Seasonal distribution of the tribe Tendipedini in Kellogg Forest Pond "2."

large tendipedid species the graphs representing abundance of adults and larvae approximated each other very closely. (Fig. 1).

STATISTICAL ANALYSIS.—A statistical examination of the data from the four most important taxonomic groups has been made by analysis of variance. The purpose of this consideration was to determine whether any significant differences in catch existed among the different traps. The total emergence in numbers of adult insects from a ½-square-yard area during each month was used for these determinations. Because of the recorded zero emergence during certain months as well as an apparent correlation of the mean values with the variance, a logarithmic transformation was used. The actual transformation used was the logarithm of (X+1) as recommended by Bartlett (1947) and used successfully by Ball & Hayne (1952).

An analysis of variance was arranged to test the differences among stations and among months for the dipterous tribes Tendipedini and Calopsectrini, the subfamily Pelopiinae and the family Heleidae. Differences among traps were further considered in respect to the various types of adult traps.

The analysis of variance shows that no significant difference existed among the tent, 1-square-yard funnel, ½-square-yard funnel and suspended ½-square-yard funnel traps when used to sample adult specimens of the tribes Tendipedini and Calopsectrini and the subfamily Pelopiinae in Lake City pond B. The F test shows differences among the traps used to sample the adult specimens of the family Heleidae to be significant at the 5% level. Further analysis of these differences between the traps used to sample heleid specimens shows that a highly significant difference existed when the tent trap catch was compared with those of the three funnel traps. No significant difference existed among catches of the three funnel traps used to sample heleid adults. The low numbers of heleids captured by the funnel traps dictates caution in interpretation of these results.

The F test shows differences among monthly values of the tribes Tendipedini and Calopsectrini to be highly significant. This results from the marked seasonal fluctuations in adult emergence for these two taxonomic groups. The analysis of the difference among months for the subfamily Pelopiinae and the family Heleidae indicates that no significant difference existed. This corresponds with the fact that the emergence of adult insects of these two taxonomic groups followed a rather uniform pattern during the investigation.

At station a in the Lake City reservoir and station III in Kellogg Forest pond 2, the emergence from only two types of adult traps were compared by a "t" test of paired comparisons. The test is based on differences in the numbers of adult insects emerging into the two adult traps during each sampling period when captures were made. Use was made of the same logarithmic transformation described with the analysis of variance data. There was no significant difference between the funnel trap and tent trap used in sampling the emerging adults of the tribe Tendipedini at the Lake City reservoir station a. The "t" value of 1.65 with 17 degrees of freedom indicates that we could expect such a value between 10 and 20 per cent of the time by chance of sampling alone.

The "t" value for the funnel tent trap comparison of the emerging adults at Kellogg Forest pond 2, station III indicates that a highly significant difference occurred. The "t" value which resulted, when the Tendipedini emergence in the funnel and tent traps was compared, was 4.08 with 7 degrees of freedom. We might expect such a high "t" value to occur naturally less than 0.1 per cent of the time in such a population. Kellogg Forest, station III, was the only location where a significant difference existed when the funnel and tent traps were used to capture emerging adults of the tribe Tendipedini.

SUMMARY.—The tent and funnel traps were equally successful in making a quantitative and qualitative estimation of all taxonomic groups sampled during the study with the exception of the adults of the family Heleidae (Diptera) and order Ephemeroptera.

There was no significant difference in the number of insects captured when suspended funnel traps were compared with funnels placed on the pond bottom.

The species of the family Heleidae were consistently more numerous in the tent trap samples.

The adult trapping devices were adequate for making qualitative but not quantitative estimations of the Ephemeroptera population.

When the adult and immature insect populations in a pond were sampled to the same degree the emergence patterns of individual species and higher taxonomic groups could be predicted equally as well with the adult insect samples as with the conventional bottom deposit samples.

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Control of Mosquito Larvae in Rice Fields with Water-Soluble Phosphorus Insecticides[1]

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Field tests made in California pastures (Gahan & Mulhern 1955) demonstrated that water solutions of the phosphorus compounds Bayer L 13/59 and Shell OS 2046[3] effectively controlled floodwater *Aedes* mosquitoes when introduced into irrigation water as it flowed into the fields. Bayer L 13/59 at concentrations of 3 and 1 p.p.m. and Shell OS 2046 at 1 p.p.m. gave 99.9 to 100 per cent control, but incomplete control was obtained with Bayer L 13/59 at 0.1 p.p.m.

Another field study was conducted in July and August 1955 in the vicinity of Stuttgart, Ark., to evaluate the effectiveness of these and other water-soluble phosphorus insecticides against mosquitoes breeding in rice fields. Bayer L 13/59, Shell OS 2046, DDVP[4], and parathion were applied to the irrigation water before it reached the fields. DDVP is a recently developed insecticide that has sufficient solubility and toxicity to be of promise as a water-soluble larvicide. Parathion has a much lower solubility but a higher toxicty than the other materials, and is the cheapest and most readily available of the chemicals found highly effective in laboratory tests (Gahan *et al.* 1955b).

Once or twice during the growing season the rice fields are drained, dried, and reflooded in an effort to control the rice water weevil, *Lissorhoptrus simplex* (Say). Since the frequency and timing of this cycle varies with the individual farmers, excellent habitats for the development of tremendous populations of floodwater mosquitoes are present throughout July and August. Horsfall (1942) found that four species comprised 98 to 99 per cent of the mosquitoes breeding under these conditions. Between 83 and 94 per cent of his light-trap collections were *Psorophora confinnis* (L.-Arr.) and *discolor* (Coq.). The eggs of both species are laid on damp soil and after 4 days are ready to hatch at the next flooding. *Anopheles quadrimaculatus* Say and *Culex erraticus* D. and K., which lay eggs on the surface of the water in flooded fields, are also prevalent, but less numerous.

In the Stuttgart area rice is grown in large fields that are not quite flat. To compensate for the slight variations in altitude, contour levees 1 or 2 feet high are constructed, dividing the fields into plots of more uniform altitude. Most of the farmers now introduce the water into the highest plot and let it flow to successively lower parts of the field through shallow cuts in the levees. This arrangement was unsatisfactory for experimental work, as only one treatment could be applied in an entire field, and no provision could be made for an untreated check. However, the five fields that were used had canals running along one edge at right angles to most of the transverse levees. With this arrangement the banks could be broken at various points and more than one treatment applied to the same field, and a portion could also be retained as an untreated check.

EXPERIMENTAL PROCEDURE.—Initial applications were

PAID PAPER

[1] Accepted for publication October 10, 1955. This work was conducted under funds allotted by the Department of the Army to the Entomology Research Branch.

[2] The writers are indebted to C. V. Bowen, Paul L. Davis, and George J. Block for development of the solubilized parathion formulation that was used. The Chemagro Corporation supplied the Bayer L 13/59, the Shell Development Company the Shell OS 2046, and the Montrose Chemical Company the DDVP.

[3] 2-carbethoxy-1-methylvinyl dimethyl phosphate.

[4] Dimethyl 2,2-dichlorovinyl phosphate.

made to the individual plots between levees, usually comprising 1 or 2 acres. In later tests parathion and L 13/59 were applied to blocks of adjacent plots, comprising 17 to 20 acres. Most of the plots were irregular in shape, and no attempt was made to measure the actual surface. Since the principal point to be determined was whether the insecticide would control mosquito larvae after the treated water had traveled long distances, the distance the chemical moved through the canal and field was recorded in all tests.

The chemicals were added to the irrigation water on a parts-per-million basis with the automatic applicator described by Gahan *et al.* (1955a). All applicators were standardized to deliver between 52 and 55 ml. of solution per minute, and the amount of insecticide applied was controlled by varying the concentration in the 55-gallon drum that served as the reservoir. The applicator usually was set up some distance from the plots at the point of greatest turbulence, where large, calibrated pumps emptied 500 to 1200 gallons of water per minute into canals. However, the DDVP treatments and those with L 13/59 and OS 2046 on the Weaver farm were introduced into the canal just before the water entered the plots. The parathion was used as a solubilized concentrate containing 1 part of parathion to 4 parts of Triton X-100. No difficulty was experienced in getting it to dissolve in the irrigation water at the low concentrations required to kill mosquito larvae. L 13/59, OS 2046, and DDVP were sufficiently soluble without additives.

The effectiveness of the treatments was determined by dipping for larvae in the treated and nearby untreated plots on the first and second days after flooding. In the smaller plots 100 dips were made each day, but on large acreages the number of dips always exceeded 500. A percentage control figure was based on the supposition that larval densities in the treated and untreated areas would have been identical had no insecticide been applied.

TESTS IN SMALL PLOTS.—As shown in table 1, solubilized parathion, Bayer L 13/59, and Shell OS 2046 successfully eliminated all *Psorophora* larvae at one or more of the concentrations used, and infestations in the untreated portions of the fields were sufficiently high to demonstrate clearly that the insecticides were responsible for the results obtained. Parathion was effective at the lowest concentrations, and gave complete control at 0.01 p.p.m. after a flow of more than ½ mile through a canal and 400 feet through the field. In this test all the larval counts were made within 10 feet of the levee that separated the treated and untreated water. A high degree of control also occurred in the plots treated at 0.005 p.p.m., and some control was indicated at 0.0025 p.p.m.

L 13/59 eliminated all the *Psorophora* in the single plot treated at 0.5 p.p.m., and in one of the plots treated at 0.25 p.p.m. In the other plot at this concentration and both of those treated at 0.1 p.p.m. reductions ranged between 95 and 99 per cent.

OS 2046 eliminated all *Psorophora* larvae in the two plots treated at 0.25 p.p.m., and good control was obtained at 0.1 p.p.m. In one test with OS 2046 at 0.25 p.p.m. the insecticide flowed 0.3 mile through a canal and 0.3 mile through the rice field.

DDVP was tested at 0.1 and 0.05 p.p.m., since it had been effective at lower concentrations than L 13/59 in laboratory tests. Although good control was obtained at each concentration, live *Psorophora* larvae were found in all plots. Most of the larvae were collected within 50 feet of the point most distant from the applicator and none were found within 700 feet of it. Although these observations suggest that the compound evaporated or decomposed before reaching the bottom of the field, it was nevertheless about as effective as L 13/59 and OS 2046 at 0.1 p.p.m. and might be completely effective at higher concentrations.

TESTS ON LARGE BLOCKS.—One-half of a 20-acre block on the Sebrees farm was treated with Bayer L 13/59 at 0.5 p.p.m. and the remainder with parathion at 0.02 p.p.m. In this test the chemical moved 1.3 miles through a canal to reach the field, and as much as another 2500 feet through the rice. At frequent intervals while the treated water was being applied the mosquito density in the field was measured. Newly hatched larvae were plentiful in areas that had been flooded only a few hours, but no larvae were found in 1,650 dips made 24 to 48 hours after the insecticide had been applied.

The portion of this field intended to serve as a check became accidentally contaminated with treated water from the canal and could not be used. One week later a larger, adjoining block was flooded with untreated water, and more than 1300 *Psorophora* larvae were collected in 200 dips made after 24 to 48 hours.

A 17-acre block on the Weaver farm was treated with parathion at 0.02 p.p.m., and the chemical moved approximately 0.6 mile through a canal and more than 2000 feet through the field. Numerous larvae were found in the treated area a few hours after flooding, but none were found in 550 dips made 24 to 48 hours after treatment. Three plots in this field were flooded with untreated water to serve as a check, and 1,346 larvae were collected in 200 dips after 24 to 48 hours.

RESIDUAL TOXICITY OF PARATHION, BAYER L 13/59, AND SHELL OS 2046.—A week after treatment collections were made in small plots treated with parathion at 0.01 p.p.m., L 13/59 at 0.5 p.p.m., OS 2046 at 0.25 p.p.m., and the untreated check plots. The results of these collections appear in table 2. *Anopheles quadrimaculatus* larvae were

Table 1.—Control of *Psorophora* larvae in small rice-field plots with soluble or solubilized insecticides.

Insecticide (p.p.m.)	Farm	Larvae per Dip: Treated Plot	Larvae per Dip: Untreated Plot	Per Cent Control	Feet Treated Water Flowed in—: Canal	Feet Treated Water Flowed in—: Field
Parathion (solubilized)						
0.01	Sebrees	0	2.43	100	3168	400
.005	McCauley	.005	14.55	99.9	270	1860
	Erstine	.07	1.80	96	3960	450
.0025	McCauley	2.71	14.55	81	250	1350
Bayer L 13/59						
0.5	McCauley	0	14.55	100	75	1080
.25	Do.	0	3.97	100	450	600
	Gray	.18	5.35	97	510	2700
.1	McCauley	.15	14.55	99	234	1725
	Weaver	.33	6.73	95	0	660
Shell OS 2046						
0.25	Brechtal	0	1.67	100	1584	1584
	McCauley	0	3.97	100	126	444
.1	Do.	.33	3.97	92	500	1300
	Weaver	.62	6.73	91	0	750
DDVP						
0.1	Weaver	0.22	6.73	97	0	1050
		.67	6.73	90	0	1100
.05	Do.	.06	6.73	99	20	1200
		.67	6.73	90	20	1250

Table 2.—**Abundance of *Anopheles* and *Culex* larvae in treated and untreated plots 1 week after application of insecticide.**[a]

Insecticide (p.p.m.)		Farm	*Anopheles* Larvae		*Culex* Larvae	
			Treated Plot	Untreated Plot	Treated Plot	Untreated Plot
Parathion	0.01	Sebrees	0.30	0.19	0	0
Bayer L 13/59	0.5	McCauley	.36	.20	0.04	0.04
Shell OS 2046	0.25	Do.	.37	.20	.15	.04

[a] Average number in 100 dips at each location.

found in every plot and were more numerous in the treated plots than in the checks. *Culex erraticus* larvae were also collected in the L 13/59 and OS 2046 plots and their checks, but none were found in the parathion plot or its check.

PHYTOTOXICITY.—There was no apparent damage to rice from any of the treatments.

DISCUSSION.—Although the residual toxicity of the treatments was insufficient to control *Anopheles quadrimaculatus* and *Culex erraticus* larvae, the tests demonstrated conclusively that water-soluble insecticides applied to irrigation water before it reaches the rice field can eliminate all floodwater (*Psorophora*) mosquitoes. Solubilized parathion appears to be the outstanding larvicide, as it is cheap, readily available, and so much more toxic than the other materials that less chemical is needed to treat a field. Except while the concentrate is being poured into the reservoir of the applicator, there is little danger connected with its use, owing to the low concentration that is required in the irrigation water to kill *Psorophora* larvae.

This application method is much safer for mosquito control personnel than spraying or dusting, as the chemicals are added to the irrigation water within a few inches of the surface and it is unlikely that the face or body will ever be contacted. The writers have observed chickens and dogs (including the senior author's dog) drinking from fields treated with parathion at 0.02 p.p.m., but received no reports of any injury to them.

The largest area treated in this study was 20 acres, but there are rice fields that contain 90 to 100 acres. One or two of the highly effective treatments were applied to the small plots on days when the air temperature in the shade registered above 100° F., but maximum temperatures were below 95° at the time the tests were conducted on the large blocks. Since high temperatures increase the rapidity with which the phosphates decompose, there is still a possibility that on extremely hot days treatments of this type may lose their effectiveness before reaching the most distant parts of the largest fields.

Should difficulty be encountered in obtaining complete control in large acreages of rice, reversion to some of the watering practices formerly employed may serve as a remedy. If levee cuts are made in a straight line through the field instead of being staggered, the treated water will flow by the most direct route to all portions of the field. In other instances it may be desirable to restore the canal along the edge of the field to permit watering of the rice in smaller blocks. These methods are still used on some farms, but have been discontinued on others.

SUMMARY.—A study was conducted to evaluate the effectiveness of water-soluble larvicides for the control of mosquitoes in Arkansas rice fields. All treatments were applied with an automatic applicator to the irrigation water before it entered the fields.

Against floodwater *Psorophora* solubilized parathion was completely effective at 0.01 p.p.m. after a flow of more than ½ mile through a canal and 400 feet through a rice field. A high degree of control also occurred in plots treated at 0.005 p.p.m., but some live larvae were found. Bayer L 13/59 and Shell OS 2046 gave 100 per cent control at 0.25 or 0.5 p.p.m., and DDVP was highly effective at 0.05 and 0.1 p.p.m. This species was controlled in large fields after the chemically treated water had traveled more than a mile in a canal and 2,500 feet through the rice.

None of the treatments had sufficient residual toxicity to be effective against *Anopheles quadrimaculatus* Say or *Culex erraticus* D. and K. 1 week after treatment.

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PRICES OF REPRINTS

Please see the December 1955 BULLETIN for the revised price schedule for reprints of papers accepted for publication after January 1, 1956.

Bionomics of *Therioaphis maculata* (Buckton) in Israel[1]

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Of the three aphid species which occur in noticeable numbers on alfalfa and berseem fields in Israel, namely *Macrosiphum pisi* (Harr.), *Aphis craccivora* Koch, and *Therioaphis* (*Myzocallis*) *maculata* (Buckton), only the latter has been recorded as even occasionally causing severe damage in Israel. The latter aphid appears to be the same species that has recently caused severe damage to alfalfa in southwestern United States under the name of "yellow clover aphid" or "spotted alfalfa aphid." In the United States it has been called *Myzocallis trifolii* (Mon.), *Therioaphis ononidis* (Kalt.) or, more recently, *Therioaphis maculata* (Buckton). During the last three decades, since it has been identified here (Bodenheimer 1930), three such outbreaks have occurred. One was in the Jezreel Valley during the late spring of 1936 (Rivnay 1948) and there were two smaller ones during the summers of 1952 and 1953 in the southern Coastal Plain. During all other years the populations remained at a level lower than the threshold of economic importance.

This paper is based upon a close study of the biology of *Therioaphis maculata*, carried out at the Entomological Laboratory of the Agricultural Research Station, Rehovot, during 1946–48. Laboratory studies were accompanied by systematic field observations carried out at the Givath Brenner Farm, 3 miles south of Rehovot.

METHODS.—The aphids were individually reared on live alfalfa plants of the Hairy Peruvian variety, growing in flower pots and caged in hurricane-lamp chimneys with cheesecloth-covered tops. The pots were placed on an open porch, thus being exposed as far as possible to outdoor conditions. The cultures were examined daily.

DEVELOPMENT.—Out of some 500 individuals which matured in the cultures during the course of study, only two developed into alate specimens, both under overcrowded conditions. Therefore, all data presented relate to the apterous viviparous form only. It should be noted that no sexual forms have been seen in this country, neither in laboratory cultures nor in the field. This species reproduces parthenogenetically throughout the whole year.

The nymphs can feed and develop on any green part of the host plant, from the young seed-leaves to the hardening stem. However, the nymphs, like the adults, prefer the lower surfaces of the leaves. No significant differences in duration of development have been established between nymphs developing on different parts of the plant.

The relationship between temperature and development is demonstrated by the asymptotic Hyperbola A in figure 1. A similar curve drawn from empirical points closely coincided with the theoretical one drawn in figure 1, the latter being based on Bodenheimer's formula (Bodenheimer 1924) $T(t-c)=Const.$ where T represents duration of development in days; t the corresponding average temperature, and c the temperature threshold of development. The dimension of the constant, better known as the Thermal Constant (Th. C.) being "day-degrees."

The only discrepancy between the empirical and the mathematical curves becomes apparent when the average temperature reaches 26.5° C., at which point the empirical curve inflects towards a slightly longer duration of development due to excessive heat. For better comprehension of figure 1 reference should be made to the monthly mean temperatures for the Rehovot area, as listed in table 1.

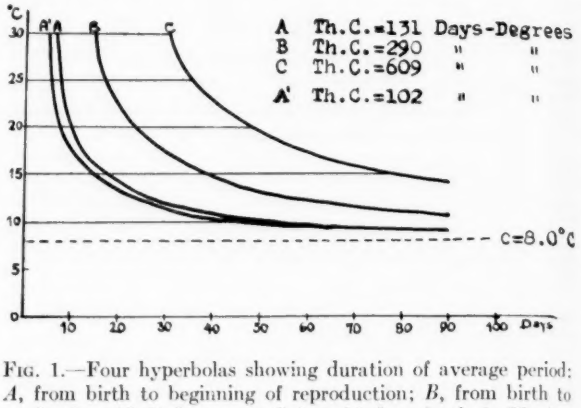

FIG. 1.—Four hyperbolas showing duration of average period: *A*, from birth to beginning of reproduction; *B*, from birth to production of half the young; *C*, from birth to death, in *Therioaphis maculata*. *A* shows minimum duration; *c* shows threshold of development.

Normally the nymph moults four times during its development. Only in cases of abnormal development, due to pathological changes in the host plant, are one or two additional ecdyses necessary for the completion of development. Since parturition usually starts on the same day, or the day following that of the last moult, a preoviposition—or still better, preparturition—period hardly exists. Only in exceptional cases preparturition lasted more than 2 days. The maximum recorded was 4 days following a 22-day period of development in winter.

REPRODUCTION.—The length of the reproductive period is determined mainly by two factors: (a) the female's fertility; (b) the rate of reproduction, i.e., the number of births per day. Numerical values of these two factors are shown in table 1.

Time from birth to the beginning of reproduction, and the number of young per day early in adult life, are the factors to watch for potential population increase. The relationship between the temperature and the length of the period from an aphid's birth to the birth of half her young, is shown by Hyperbola B in figure 1. Hyperbola C shows the same relationship for total longevity.

As a rule, half the number of offspring is born by the end of the first third of the reproductive period. This can be expressed by the following formula, $B=A+(C-A)/3$ where A represents the average duration of development, B the period between birth and the completion of bearing half the young, and C the total longevity. Furthermore, even the respective Thermal Constants of these three

[1] Accepted for publication August 15, 1955. This paper was sponsored by the Department of Entomology, University of California, Riverside, and substantially revised by staff members to meet requirements for publication here.

[2] Junior Lecturer in Economic Entomology.

Table 1.—Development and reproductive rate of *Therioaphis maculata* (Buckt.) on alfalfa at Rehovot.

Month	Monthly Mean Temperature °C.	Development (Min./Max.) Days	Fecundity Young per ♀	Reproduction Period Days	Birth Rate Young/♀/Day	Per Cent Nymphs (Field)
January	13.1	25.6 (23/29)	78	46.5	1.7	75.0
February	14.7	19.0 (16/25)				
March	17.6	12.5 (10/15)	115	28.0	4.1	88.0
April	18.8	11.0 (9/13)	109	26.6	4.1	83.0
May	23.1	8.5 (7/11)	116	24.0	4.8	89.0
June	24.9	7.8 (7/10)	114	25.0	4.6	89.5
July	26.3	7.4 (6/9)	108	25.1	4.3	90.0
August	26.9	8.1 (7/11)	72	21.8	3.3	84.0
September	26.3	8.4 (7/10)	27	13.5	2.0	73.0
October	22.7	8.9 (7/12)	93	22.3	4.2	85.0
November	20.6	10.2 (9/13)	99	33.0	3.0	77.0
December	15.3	17.1 (15/22)				

periods conform perfectly with this formula, as $290 = 131 + (609 - 131)/3$ (see Fig. 1).

The highest number of young produced by an individual female in a single day was nine. The same female, which developed at the end of June, also had an average of 7.3 young per day, the highest rate recorded. The highest total young production was also during July by another female that gave birth to 160 young.

Out of the 500 females which matured during the course of study only two were entirely sterile. They both developed in September, living 31 and 34 days at a period when 37 days was the average longevity.

Generally a female does not die immediately at the end of her reproductive period. The period of senescence tends to occupy proportionately more of her life in summer than in winter, but its absolute length is greater in cold weather. Among contemporary females those with the more rapid reproductive rate tend to complete reproduction sooner and to have a longer "retirement period." This is illustrated by two females born May 21, 1947. Each required 8 days to mature. One of them produced 123 young in 24 days and lived 6 days thereafter (total, 38 days) while the other produced 119 young in only 18 days and then "retired" for 14 days before death (total 40 days). The longest period of senescence recorded was 29 days.

The effect of *khamsin*[3] on the reproduction of this aphid is quite remarkable. A severe *khamsin* is lethal to many aphid species, including *Therioaphis maculata*, often killing more than 90 per cent of the population. A less severe *khamsin* rather increases the rate of reproduction during its actual prevalence, but leaves a pronounced aftereffect of low productivity, from which the aphid never recovers, as graphically illustrated in figure 2. Females I and II of figure 2 were of equal longevity and duration of development. Their fecundity was practically the same (84 vs. 81, respectively). The mean temperature during their lives was also similar (27° C. vs. 26.5° C.). Female I was affected by a *khamsin* prevailing during the 9th to 13th day of her life, which upset the normal symmetrical trend of the rate of reproduction. In normal cases the ratio of segments $\overline{BC}:\overline{AB}$ always equals 2:1, whether in summer (female II) or in winter, whereas in the *khamsin* case this ratio grew to 24:7 or 3.4:1.

ANNUAL NUMBER OF GENERATIONS.—Based upon the hyperbolas of figure 1, the annual number of generations

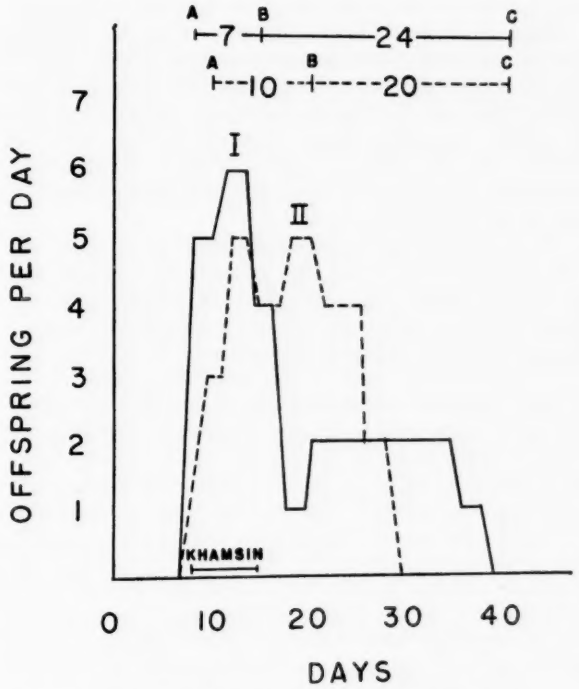

FIG. 2.—Life history and reproduction record of two *Therioaphis maculata* females that lived during the summer. Aphid I lived through a *khamsin* wind, while aphid II did not.

can be calculated for any given locality, provided that meteorological data are available. The annual number of generations can be worked out according to each of the four hyperbolas but, as stated above, Hyperbola B should be applied for epidemiological purposes. The sequence of generations in the Rehovot area is shown in table 2.

Values worked out according to Hyperbola A are not shown but they amount to 45 generations per year, as compared to 41 generations empirically bred in the laboratory. This discrepancy is surprisingly small considering the numerous inevitable technical errors involved in breeding such a high number of generations.

[3] An extreme weather condition well-known in the Middle East characterized by hot and dry desert winds. Temperatures may rise to over 40° C. in the shade, and relative humidity drops to below 30 per cent sometimes to 5 per cent.

Table 2.—Sequence of generations of *Therioaphis maculata* at Rehovot, Israel.

Month	Generations of Minimum Length		Generations of Mean Length[a]		Generations of Maximum Length	
	Gen. No.	Days/ Gen.	Gen. No.	Days/ Gen.	Gen. No.	Days/ Gen.
January	1–2	26	1	50	1	87
February	2–3	24–18	1–2	50–53	1	87
March	3–5	14–13	2–3	33–30	1–2	87–49
April	6–8	12–10	3–4	30–21	2	49
May	8–11	10–8	4–5	21–19	2–3	49–38
June	12–15	8	5–7	19–17	3–4	38–34
July	16–19	7	7–9	17–16	4–5	34–32
August	20–24	7	9–10	16–15	5	32
September	24–28	7	11–13	16–19	6	35
October	28–31	9	13–14	19–23	6–7	35–43
November	32–34	10	14–15	23–30	7	43+
December	35	17+	15+	30+	7+	—
Totals	35		15		7	

[a] Duration of mean-length generation is from birth of female to birth of half her young.

FIELD COUNTS.—These were carried out in an irrigated pasture consisting of alfalfa growing together with Rhodes and Paspalum grasses. At fortnightly intervals samples of 100 alfalfa stalks were picked at random and the number of aphids found on them recorded. Results of these counts are illustrated in figure 3. The observation field was grazed by cattle at the usual frequency, dates of which are indicated in the figure.

The census revealed three peaks in the population, during March, June, and November, with a distinct ebb during September and January. Measurements of the length of the alfalfa stalks at each sampling date showed that almost every grazing was followed by rapid growth of the plant which subsequently led to an increase in the aphid population. Upon cessation of growth the number of aphids immediately dropped, sometimes long before the following grazing. During the winter (Dec. 1946–Feb. 1947) the growth of the alfalfa was particularly retarded, following a short initial regeneration, thus resulting in a constant drop in the aphids' population. It should be mentioned that on two occasions (marked M) the field was not grazed, but mowed and dried for hay. This practice involves a great deal of vibration of the plants, as a result of which many aphids are shaken off to the ground. Those not shaken off can still leave the drying alfalfa and settle on the regenerating stubble. Contrary to this, in the case of grazing, very many aphids are actually swallowed by the cattle, reducing the population. In starvation tests, 40 per cent of the nymphs survived 16 hours but none survived 22 hours.

WINGED FORMS.—Alate viviparous females appeared in the field twice throughout the year, once during the whole month of June and the first half of July, and again from mid-September till the end of November. The winged specimens appeared about a fortnight before the peak in the population was reached. Even at the height of their appearance (September) their number is still smaller than that of the apterous females, the rate being 3:7. The winged females raised in the laboratory did not differ from the wingless ones as regards longevity or fecundity.

NATURAL ENEMIES.—The common aphid predators of this country, namely *Coccinella 7-punctata* L., *Coccinella 11-punctata* L., various syrphid larvae, and the larvae of the lacewing *Chrysopa carnea* Steph. were observed to be active among the colonies of this aphid mainly during the population peaks. Hymenopterous parasites of the Braconid genus *Praon* also occurred at the same periods. Field estimates of the incidence of hymenopterous parasites showed them to be numerous in June and November–December, 1946, and in March, June, and November, 1947. It was noted that the parasites' appearance in recognizable numbers invariably lagged a fortnight behind the ascending phase of the aphid peak. This indicates the parasites' inability to restrain the build-up of the peak in the aphid's population. The question whether the role of the parasites in the breakdown of the peak is primary or secondary is still open.

AGE GROUPS.—The percentage of nymphs in the population stands in close agreement with the seasonal changes in birth rate in the laboratory cultures (Table 1). The only exception is in May, when the rate of reproduction is the highest. At this time adult longevity is short and yet, contrary to expectation, the nymph percentage in the field is not the highest, but is slightly lower than during the two following months. This is due to the particularly high mortality of young nymphs in the field during May, which is most frequented by *khamsins*.

HOST RELATIONS.—*Therioaphis maculata* has so far been found here only on cultivated clover and alfalfa. The alfalfa commercially grown here is of the Hairy Peruvian variety and the only clovers grown here are the two varieties of berseem (*Trifolium alexandrinum*), namely *Fahli* and *Miskawi*. Comparisons of the duration of the aphid's development on the two clover varieties and the alfalfa, carried out at three different times of the year, showed no significant differences.

Another experiment concerned nine alfalfa varieties, the seeds of which had been sent to the Rehovot College

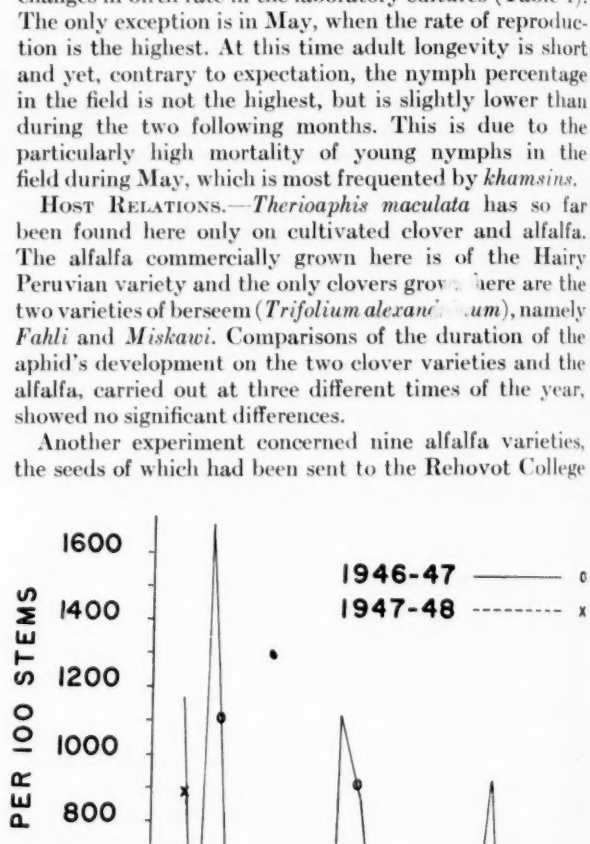

FIG. 3.—Populations of *Therioaphis maculata* on alfalfa at Givath-Brenner, near Rehovot, from June 1946 to April 1948. Dates of grazing (*o* or *x*) are indicated, as are the two mowings (*M*); one in 1946 and one in 1947.

Table 3.—Results of placing seven *Therioaphis maculata* on caged plants of various varieties of alfalfa.

Variety	Origin of Seed	Aphids per 1,000 Leaves[a]	Extent of Sooty Mould[a]	Days from Infestation to Death of Plants
Hardigan	Idaho	Innumerable	Abundant	27
Grimm	Colorado	7820	Abundant	35
Chilean	Arizona	5340	Abundant	30
Meeker Baltic	Colorado	4150	Fair	41
Ladak	Idaho	2250	Fair	45
Cossack	Idaho	1970	Abundant	39
Hairy Peruvian	Arizona	1950	Little	41
Ranger A/136	Montana	1680	Fair	79
Hardistan	Colorado	270	None	over 250

[a] Records were made after 30 days.

of Agriculture from the United States. In mid-September, these seeds were sown in large flower pots, each placed in a spacious wire-screen cage. After germination they were thinned out to 10 plants per pot. When one-month old the plants were infested with seven fourth-stage nymphs to each pot. Thirty days later, counts, as well as damage assessments, were made. Results are given in table 3.

It should be noted, however, that such an enormous population density as obtained inside the cages is never reached in the field, except in outbreak times. Sooty mould developed in noticeable amounts only when population densities reached higher than 1500 per 1000 leaves. A density as high as this was never encountered in the field during the two observation years, thereby explaining the lack of economic importance of this aphid in normal years.

Five of these varieties (Hardigan, Grimm, Meeker Baltic, Hairy Peruvian, Hardistan) were tested in small field plots where they were exposed to natural infestation by *T. maculata*. Aphid counts were made at the end of 17 months, during which the plots had been cut regularly for hay. At this time the Hardistan variety showed the poorest growth, $6\frac{1}{4}$ inches against 15 inches for Hairy Peruvian, even though the aphid population on it was well below the average for the five varieties. The Hardistan variety is obviously not well adapted to conditions in Israel.

As regards the tolerance of the alfalfa plant to this aphid's attack, a case was witnessed when a single leaflet, the total area of which amounted to no more than 123 mm.^{2}, was found to support 99 aphids of all stages before it succumbed. On the other hand, when infestation rate was not higher than one aphid per 7 mm.^{2} of infested-leaf surface, no changes in the leaf could be noticed externally.

SUMMARY.—*Therioaphis maculata* (Buckton) only occasionally damages alfalfa in Israel. Development was most rapid in July, while reproduction was greatest in May. Population counts showed peaks in March, June, and November. Maximum possible number of generations per year were 41. The dry, hot *khamsin* wind increases reproduction when it is mild but may cause high mortality when severe. Parasites and predators were observed attacking the aphids. Certain alfalfa varieties are less susceptible to injury than others.

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Control of the Spotted Alfalfa Aphid on Alfalfa in Southern California[1]

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The exact taxonomic position of the spotted alfalfa aphid, newly introduced into the southwestern portion of the United States, which has been so damaging to alfalfa has only recently been determined to be *Therioaphis maculata* (Buckton). Heretofore this insect has been termed the yellow clover aphid and referred to as *Therioaphis* (or *Myzocallis*) *trifolii* (Monell).

The yellow clover aphid found in the eastern and midwestern United States has been known for many years and has been reported by a number of workers, notably by Davis (1914), to be primarily a pest of clovers and not of alfalfa. The southwestern form, on the other hand, is primarily a pest of alfalfa and not of clovers. It has been exceedingly injurious to all commercial varieties of alfalfa in California except the northern alfalfa variety Lahontan, which seems to exhibit a certain amount of resistance. Dickson & Reynolds (1955) report that it also attacks bur clover (*Medicago hispida*), sour clover (*Melilotus indica*), black medic (*Medicago lupulina*), and to some extent berseem (*Trifolium alexandrium*). Most other species of clover (such as red and Ladino), trefoil and vetch are not suitable hosts.

This southwestern form behaves more like species reported from India by Buckton (1899) and Das (1918), and from the Mediterranean area by several entomologists including Theobald (1915). It is possible that it was introduced into the southwestern part of the United States from one of these areas.

The spotted alfalfa aphid was first collected in California from bur clover in San Diego County in February 1954 by Armitage. Although the aphid is found readily in coastal areas it does not appear to be a pest of predictable importance in such localities. It is not known at present whether this is due to the environmental limitations of the pest or to predator activity particularly by coccinellids. In the late spring of 1954 this aphid was reported to be causing injury to alfalfa in parts of New Mexico and in the Yuma area of Arizona (Tuttle & Butler 1954). In June it was causing extreme damage in the Imperial Valley of California. From this heavily

[1] Paper No. 871, University of California Citrus Experiment Station, Riverside. Accepted for publication July 30, 1955.

infested area it spread rapidly over the cultivated areas of the Colorado desert and into most of southern California. In the spring of 1955 it was reported in restricted areas of the southern San Joaquin Valley. As in the case with many newly introduced pests this aphid built up rapidly to large populations, but now seems to be settling into something of a less injurious annual pattern. At this early date it appears as if the aphid may be a pest in the spring and fall of the year in hot areas such as Imperial Valley, and a summer pest in most other areas.

Soon after the spotted alfalfa aphid appeared in the Imperial Valley it became evident that the development of control measures was essential. The tests reported in this paper were therefore undertaken.

CROP INJURY.—Injury to alfalfa as a result of spotted alfalfa aphid feeding is much more severe than that resulting from attacks by other aphids such as the pea aphid, *Macrosiphum pisi* (Kltb.). In its feeding process, the spotted alfalfa aphid apparently injects a toxin into the plant. This is particularly evident in small seedling alfalfa, as relatively low numbers of aphids may completely kill out the stand in a field in a very short time. Further evidence of a toxic secretion is the abnormal amount of leaf yellowing and dropping caused by this aphid on larger plants. Since this species prefers the lower leaves, these parts of the plant are affected first, and leaf drop progresses up the plant as the aphid moves up.

In addition to leaf drop, there may be several other types of injury to older alfalfa. When the aphids are abundant, the copious amounts of honeydew which they secrete may completely cover the stems, leaves, and ground. At times, mowing and baling machinery have become so sticky that it has been necessary to wash or steam-clean them thoroughly. When honeydew is so abundant that normal baling is impossible, growers may be forced to bale completely dry hay, thus suffering a further loss in quality. The honeydew provides an ideal medium for the development of the inevitable black sooty-mold fungus, which, when abundant, makes the hay unpalatable to livestock. When plants are cut after a heavy aphid infestation, regrowth is weak and delayed. If the infestation is allowed to persist, plant growth may be stopped. Such a situation eventually results in the death of many plants and causes a seriously depleted alfalfa stand. There is some evidence that such stand depletion is aggravated by the invasion of the weakened roots by soil fungi.

MATERIALS AND METHODS.—Tests with commercially available insecticides (Tables 1–4) were conducted in field plots in the Imperial and Palo Verde valleys of Riverside County, as well as in the greenhouse at Riverside. A problem of toxicity to pollinating insects was anticipated, as some of the best of the commercially available aphicides are highly toxic to honey bees. To minimize the hazards of drift onto apiaries and forage plants of the pollinators, most of the insecticides were applied as sprays.

Where ground application equipment was used, treatments were replicated four times in each test. Where aerial equipment was used, large blocks were treated and were replicated either twice or not all at. Because of the extreme destructiveness of the spotted alfalfa aphid, untreated areas were not left in the airplane-treated fields.

In the large nonreplicated blocks, subsamples were taken in the counting process. In practically all cases, counts were made by cutting alfalfa stems below the lowest leaves and recording the number of apterous aphids. Because of this aphid's tendency to jump off the plant when disturbed, care was necessary in cutting the alfalfa stems.

Ground sprays were applied by means of a Yellow Devil Sprayer[2] equipped with a 27-foot boom and low-volume hollow-cone nozzles operated from the "power take-off" on the tractor. Dusts were applied by a Hardie duster[3] equipped with a 30-foot boom. Aerial sprays were applied by commercial airplane at the rate of 3.5 gallons per acre.

RESULTS.—*Test 1.*—On July 8, 1954, sprays were applied with ground equipment to alfalfa that was about 8 inches tall in plots in the Imperial Valley. Sprays were applied at the rate of approximately 5.5 gallons per acre. The spray boom was equipped with 16 nozzles, and the sprayer was operated at a pressure of 60 p.s.i. Each treatment was replicated four times, and each replicate was 27 feet wide by 225 feet long.

Treatments were evaluated 4 and 11 days after application by counting the number of apterous aphids per 100 stems. Results are summarized in table 1.

Table 1.—Effectiveness of various insecticide sprays applied by ground equipment July 8, 1954, for control of the spotted alfalfa aphid on alfalfa in the Imperial Valley, California.

Material	Pounds Toxicant per Acre	Gallons per Acre	Apterous Aphids: No. per 100 Stems, July 12	Apterous Aphids: No. per 100 Stems, July 19	Apterous Aphids: Per Cent Reduction from Check, July 12[a]
Systox	0.20	5.8	152	467	97
Parathion	0.20	5.8	389	535	93
Toxaphene	2.36	5.5	400	380	92
Endrin	0.24	5.5	445	405	91
Am. Cyanamid 12008	0.20	5.8	660	299	87
Malathion	0.71	6.5	1215	1447	77
DDT	1.20	5.5	2024	172	61
Perthane	1.20	5.5	3063	461	41
Nicotine	0.80	5.8	3901	116	29
Check	—	—	5226	126	—

[a] As a result of extremely hot weather (118° F. or higher) and/or the action of beneficial insects, the aphid population was dropping rapidly at this date.

As a result of the extremely high temperatures (maximum range between 110° and 120° F.) and/or of beneficial insects, by the time of the second count, on July 19, the aphid population had dropped sharply. Of the materials tested, Systox, parathion, toxaphene, endrin, and American Cyanamid 12008 gave excellent control, ranging from 97 to 87% reduction from the check. Malathion, contrary to results obtained in later tests, gave only a fair reduc-

[2] Engine Parts Manufacturing Company, Cleveland, Ohio.
[3] Hardie Manufacturing Company, Hudson, Michigan

tion of 77 per cent. DDT gave a 61% reduction from the check, and results with Perthane and nicotine were poor. It is thought that perhaps nicotine did not give good aphid control because low-volume gallonage rather than full-coverage sprays were used.

Test 2.—This experiment was performed on the University of California Experimental Farm in the Imperial Valley on February 1, 1955. Sprays were applied with a ground sprayer to alfalfa about 8 inches tall, at rates ranging from 6.7 to 10 gallons per acre. Each treatment was replicated four times, and each replicate was 27 feet wide by 100 feet long. The spray boom was equipped with nozzles adjusted for broadcast spraying, and the pressure was 60 p.s.i., as in Test 1.

Treatments were evaluated several times after application, the last count being made on March 17, approximately 6 weeks after application. Contrary to other tests, counts were made in Test 2 by sweeping with an insect net, in which a standard 180-degree arc was described. Eighty sweeps were made for each treatment. In the first count both winged and apterous aphids were recorded, but in subsequent counts only the number of apterous forms were recorded. Results of Test 2 are summarized in table 2.

As a result of cool weather during this test, the aphid population did not build up rapidly on the untreated alfalfa until after March 1, when a heavy migration into the field occurred. Parathion, malathion, Systox, endrin, toxaphene and diazinon gave excellent results at the rates used, while the acaricide 2,3-*p*-dioxanethiol S,S-bis (0,0-diethyl phosphorodithioate) (AC 528) gave mediocre results. The aphids began increasing rapidly about 4 weeks after treatment, and at this time none of the materials were effective.

Test 3.—This test was undertaken in the Imperial Valley on March 21, 1955. Sprays were applied as described in Tests 1 and 2, at rates ranging from 5.5 to 7 gallons per acre. Dusts were included in this test and were applied by means of a Hardie duster equipped with a 30-foot boom, at rates ranging from 20 to 41 pounds per acre. Each treatment was replicated four times, and each replicate was 30 feet wide by 250 feet long.

Treatments were evaluated on March 28 (after 7 days) and April 7 (after 17 days) by counting the apterous aphids on 80 stems for each treatment. Results are summarized in table 3.

Table 2.—Effectiveness of various insecticide sprays applied by ground equipment on February 1, 1955, for control of the spotted alfalfa aphid on alfalfa in the Imperial Valley, California.

Material	Pounds Toxicant per Acre	Gallons per Acre	No. per 80 Sweeps of Net: Apterous and Winged Aphids, February 4	Apterous Aphids: February 24	Apterous Aphids: March 1	Apterous Aphids: March 17
Diazinon	0.67	6.7	65	1	1	2,746
Systox	0.28	7.0	12	3	2	2,112
Malathion	1.00	8.0	9	9	4	1,926
Malathion	0.50	8.0	19	13	2	2,044
Parathion	0.28	7.0	29	17	10	4,768
Parathion	0.21	10.0	23	11	4	2,440
Endrin	0.34	7.0	114	21	5	2,864
Toxaphene	3.10	7.0	141	155	61	13,270
AC 528[a]	0.28	7.0	237	629	285	—
Check	—	—	292	694	1060	71,800

[a] 2,3-*p*-dioxanethiol S,S-bis(O,O-diethyl phosphorodithioate).

Table 3.—Effectiveness of various insecticide sprays and dusts applied by ground equipment on March 31, 1955, for control of the spotted alfalfa aphid on alfalfa in the Imperial Valley, California.

Formulation (Amount Toxicant per Acre)	Amount per Acre	Apterous Aphids: No. per 100 Stems, March 28	Apterous Aphids: No. per 100 Stems, April 7	Per Cent Reduction from Check, April 7
Liquid spray	*Gallons*			
Systox, 3.4 oz.	6.0	57	130	98+
Systox, 2.0 oz.	7.0	129	304	96
Meta-Systox, 4.0 oz.	7.0	59	239	97
Parathion, 3.4 oz.	6.0	229	294	96
20% TEPP, 0.94 pt. plus DDT, 0.94 lb.	6.6	419	600	93
20% TEPP, 0.94 pt.	6.0	648	1325	84
2.5% rotenone, 0.9 pt.	6.3	578	1519	82
Toxaphene, 2.4 lb.	5.5	1063	2700	67
Dust	*Pounds*			
15% toxaphene, 3.6 lb. plus 5% DDT, 1.2 lb. plus 40% sulfur, 9.6 lb.	24	173	223	97
10% toxaphene, 4.1 lb. plus 50% sulfur, 20.5 lb.	41	328	1048	87
1% parathion, 3.8 oz.	24	450	637	92
20% toxaphene, 4 lb. plus 40% sulfur, 8 lb.	20	1798	4252	48
Check	—	3473	8196	—

In this test, sprays of Systox at 3.4 and 2.0 ounces per acre, Meta-Systox (0,0-dimethyl 0-2-ethylmercaptoethyl thiophosphate) at 4.0 ounces per acre, and parathion at 3.4 ounces per acre all gave excellent results (96 to 98 per cent reduction from the check) on April 7. The addition of DDT to TEPP increased the effectiveness by about 9 per cent from 84 to 93 per cent reduction from the check. Toxaphene spray gave only fair results. The dusts used in this test, except for parathion, were materials commonly used in the desert for control of *Lygus* bugs on alfalfa seed crops. It is interesting that the toxaphene-DDT combination dust gave as good results as the best sprays and was markedly superior to either the 10 or 20 per cent toxaphene or the 1 per cent parathion dusts.

Test 4.—The alfalfa field used in this test was located in the Palo Verde Valley of Riverside County. Sprays were applied by airplane on April 6, 1955, at the rate of 3.5 gallons per acre. Each treatment was replicated twice, and each replicate was 100 feet wide and 1200 feet long. No untreated area was left. The alfalfa was young—about 6 inches high at the time of treatment.

The treatments were evaluated on April 11, 20, and 28. Each of the two large replicates per treatment was subsampled so that four records were taken for each treatment, and apterous aphids on 60 stems per treatment were recorded. Results are summarized in table 4.

Although these treatments were applied according to commercial methods there appeared to be some "skipped" plants in the parathion- and toxaphene-treated plots. It is of interest to note that Systox applied at the rate of 2 ounces per acre proved to be adequate in this test.

Test 5.—A seedling alfalfa field located in the Palo Verde Valley of Riverside County was used in this test. Spray treatments were applied on April 16, 1955, to nonreplicated blocks by airplane, as in Test 4. The plants in this field had just emerged, and the first true leaves were developing at the time of treatment. This

Table 4.—Effectiveness of various insecticide sprays applied by airplane for control of the spotted alfalfa aphid on young alfalfa (sprayed April 6, 1955) and on newly emerged seedling alfalfa (sprayed April 16, 1955) in the Palo Verde Valley, California.

Material[a] (Amount Toxicant per Acre)	No. of Apertous Aphids				
	Per 60 Stems Young Alfalfa (6 in. high)			Per 100 Plants Newly Emerged Seedling Alfalfa[b]	
	April 11	April 20	April 28	April 21	April 28
Endrin, 0.3 lb.	29	263	—[c]	215	3433
Parathion, 4 oz.	105	566	979	21	1087
Systox, 2 oz.	3	84	481	62	1057
Systox, 4 oz.	2	138	486	66	1210
Toxaphene, 3 lb.	119	1016	—[c]	—	—

[a] Applied at the rate of 3.5 gallons per acre.
[b] Much of field replanted because of extremely heavy winged aphid migration.
[c] Re-treated.

field was experiencing an extremely heavy migration of winged aphids at this time, and the plants were being killed.

The results obtained in this test (Table 4) indicate that on small seedling alfalfa, parathion is as effective as Systox, and that there is little aphid kill beyond that effected at the time of application. Results with endrin were poor, many plants being dead at the time of the second count.

Miscellaneous Tests.—A report that lime sulfur in irrigation water was controlling the spotted alfalfa aphid in certain areas led to further tests. Lime sulfur at various rates, the highest being 15.3 gallons per acre, was run in water of the first irrigation after cutting. Little or no reduction in aphid population was observed, but there seemed to be a definite inhibition of honeydew formation by the aphid.

Because of the serious nature of aphid attack on small alfalfa plants when first emerging from the seed, several greenhouse tests were made with treated alfalfa seed. The seeds were soaked in solutions for varying lengths of time at concentrations of 1 per cent and higher. Schradan was the only material not having a serious inhibitory effect on germination, but this material gave little kill of the aphid. Plants surviving in Systox and 0,0-diethyl S-isopropylmercaptomethyl dithiophosphate (American Cyanamid 3911) treatments remained free of aphids for some time. These tests are to be repeated with systemic materials impregnated on activated charcoal, and by slurrying on systemic materials with a suitable sticker.

Discussion.—Most of the commerical treatments for control of the spotted alfalfa aphid in southern California have utilized parathion, although considerable malathion has also been used. In certain areas, losses to the bee-keeping industry from the use of these materials have been marked, especially during the early spring when there is a shortage of bee-forage plants in bloom. As a result of this nectar shortage, bees have worked the aphid honeydew deposits in heavily infested fields, and when these fields were treated, bee losses resulted. In the same way, alfalfa fields in which certain weeds were in bloom were attractive to bees, and losses occurred following treatment. To minimize the drift problem into apiaries, growers are urged to use sprays rather than dusts. Materials less toxic to bees, particularly Systox, show considerable promise in the alleviation of the bee-loss problem.

When the spotted alfalfa aphid is at its peak of abundance, growers often find it necessary to re-treat fields frequently. This is usually not because of poor kills obtained from insecticide application, but because of migration into the treated fields from heavily infested neighboring fields. Grower education in recognizing the aphid problem and applying control measures when necessary has minimized this migration problem. As a result, most growers have found that during the population peak of the aphid one and occasionally two applications per cutting are sufficient.

For satisfactory aphid control, thorough treatment application has been shown to be absolutely essential. Any skipped areas in the field, along margins, around trees and buildings, etc., create potential sources for rapid reinfestation of the entire field.

In general, the spotted alfalfa aphid problem has not been as serious in alfalfa seed production as in hay production. This has been due primarily to two factors: (1) The seed is produced during the warmer time of the year when predaceous insects, primarily coccinellids, are most active; and (2) the use of toxaphene, particularly the toxaphene-DDT combinations, as used for lygus bug control, generally keeps the aphid below economic levels.

The residue problem following insecticide applications is a critical factor in alfalfa hay production. Regulations regarding the use of materials such as parathion, malathion, and Systox should be carefully followed. According to the California regulations, parathion must not be applied within 15 days of cutting, malathion within 7 days, and Systox within 21 days.

Summary.—The spotted alfalfa aphid, *Therioaphis maculata* (Buckton), newly introduced into the southwestern portion of the United States, is a serious pest of alfalfa. Trefoil, vetch, and most species of clover (such as red and Ladino) are not suitable hosts, but it will attack bur clover (*Medicago hispida*), sour clover (*Melilotus indica*), black medic (*Medicago lupulina*), and to some extent berseem (*Trifolium alexandrium*).

Crop injury is extremely serious and consists in the killing of seedling alfalfa, plant defoliation (beginning with the lower leaves), weak and delayed regrowth or complete retardation of regrowth following cutting, and seriously depleted stands of older alfalfa. When the aphid population is large, honeydew secretion may be so abundant and sticky that normal cutting and baling are impossible. Growth of the sooty-mold fungus on the honeydew may make hay unpalatable to livestock.

The spotted alfalfa aphid is easy to kill with many insecticides, but control has often been difficult to maintain because of mass migrations from neighboring fields When tested for control as sprays, the following insecticides gave excellent results at the approximate rates per acre indicated: Systox (2 to 4 ounces), Meta-Systox (4 ounces), parathion (2 to 4 ounces), malathion (8 to 16 ounces), Diazinon (11 ounces), American Cyanamid 12008 (3.2 ounces), endrin (0.3 pound); and, in most cases, toxaphene (3.0 pounds) and TEPP (1 pint) plus

DDT (1 pound). Insecticides giving moderately good results were: TEPP (1 pint), rotenone (1 pint of 2.5 per cent concentrate), DDT (1.2 pounds). Materials giving poor control were: Perthane (1.2 pounds) nicotine (13 ounces) 2,3-*p*-dioxanthio S,S-bis(0 0-diethyl phosphorodithioate) (AC 528) (4.5 ounces). In commercial practice the lower rates mentioned have been consistently successful only on short alfalfa. On very small seedling alfalfa, endrin sprays were not satisfactory.

When tested as dusts, treatment with toxaphene (15 per cent) plus DDT (5 per cent) at 24 pounds per acre gave excellent control and was superior to toxaphene (10 per cent) at 41 pounds per acre, toxaphene (20 per cent) at 20 pounds per acre, or parathion (1 per cent) at 24 pounds per acre.

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The Use of *Bacillus thuringiensis* Berliner to Control the Western Grapeleaf Skeletonizer[1]

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The appearance of the western grape leaf skeletonizer, *Harrisina brillians* B. & McD., on wild and cultivated grape in southern San Diego County was first noted about 1941. Its subsequent spread northward toward areas of commercial grape production, despite the eradication efforts of state and local agencies, was considered to constitute a serious threat to viticulture in California. Accordingly, in 1950 the University of California undertook a program of introduction of insect parasites of the skeletonizer (Smith 1953). Outbreaks of disease were noted in larvae of *H. brillians* being reared in insectaries at Fort Huachuca, Arizona, and La Mesa, California. Specimens sent to Berkeley for diagnosis resulted in the isolation of a sporeforming bacillus (possibly *Bacillus cereus* Fr. & Fr.) and a granulosis virus (Steinhaus & Hughes 1952).

In the spring of 1952 a laboratory was set up in a small unheated greenhouse at El Cajon, San Diego County, by C. G. Thompson and A. R. Logan, for the purpose of testing larvae of *H. brillians* with a number of different entomogenous microörganisms including several polyhedrosis and granulosis viruses from various lepidopterous hosts, and the Mattes' strain of the sporeforming bacterium, *Bacillus thuringiensis* Berliner. Of the organisms utilized in the feeding tests, only *B. thuringiensis* was found to be particularly virulent for the western grape leaf skeletonizer. The results indicated that the percentage mortality among half-grown larvae fed heavy concentrations of bacillus spores in laboratory tests is about 45 per cent on the eighth day and may reach a high of about 83 per cent on the twelfth day after infection.

Based on the limited findings of Thompson and Logan, studies to determine the effectiveness of the Mattes' strain of *B. thuringiensis* against the western grape leaf skeletonizer under field conditions were undertaken. The bacillus spore material used in these studies was produced in the laboratory at Albany in 1952 using methods which have been described elsewhere (Steinhaus 1951, Hall 1954). Other characteristics of this strain have been given by Steinhaus (1951) and Steinhaus & Jerrel (1954).

During the summer of 1952 the eradication program conducted by the California Bureau of Entomology was operating so effectively that field populations of larvae of *H. brillians* were impossible to find. After futile searching a small infestation was started by attaching insectary-produced egg masses to leaves of wild grape in the vicinity of Flynn Springs, east of El Cajon. Although some of the egg masses failed to hatch or were otherwise destroyed, several colonies of larvae were developed by this means.

The several masses of first-instar larvae were divided into a control group of three masses and a test group of five masses. The bacterial spray material was prepared by agitating pure spore powder in water in a blender to break up the clumps of spores and then diluting the resultant suspension to a concentration of 2 grams of spore powder per gallon of water. Application was made with a Hudson garden sprayer. Since the skeletonizer colonies are located on the under surfaces of the leaves, an effort was made to cover both sides of the leaves on which the test larvae might feed. Because of the qualitative nature of the experiment, no determination was made of rate of application. Sampling by counts of colony populations were made twice daily, at 8 a.m. and 5 p.m. for 5 days. The results are presented in table 1.

The results of this first test indicated that application of a concentrated spray of *B. thuringiensis* spores may be of value in effectively reducing the number of young

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Table 1.—Mortality of first-instar *Harrisina brillians* larvae after spraying with *Bacillus thuringiensis* spores. Summer 1952.[a]

	Percentage Mortality on Days Following Application[b]										
	0		1		2		3		4		5
Group	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Test	0	3	28	34	81	86	87	91	95	99	100
Control	0	6	8	9	9	10	14	18	27	27	30

[a] Average temperatures during test: Max. 99° F., Min. 70° F. (from U.S.D.C. Climatological Record, California Section, Alpine INNE station, August 1952).
[b] Average of 5 colonies in test group; average of 3 colonies in control group.

larvae in field populations. Heavy mortality in the test colonies was first noted at the end of the second day after treatment, and all of the test larvae were dead when samples were taken on the afternoon of the fifth day. With mortality in the check colonies ranging up to 30 per cent, the bacillus was responsible for causing at least 70 per cent mortality in the test colonies.

In the fall of 1954, an extensive build-up of *H. brillians* in an experimental vineyard leased by the University of California for biological control investigations in El Cajon valley made it possible to continue the *Bacillus thuringiensis* studies. The first test undertaken was of a qualitative nature to check the results obtained in the preliminary experiment of 1952.

The test was set up in August when early-instar larval masses were numerous. As in the preliminary study, young larvae were utilized because of their habit of remaining in compact groups, thus making possible sampling by colony counts. Twenty second- and third-instar larval colonies were tagged, one group of five as untreated controls and three groups of five for testing the effects of 1-, 5-, and 10-gram concentrations of blenderized *B. thuringiensis* spores per gallon of water. A small Hudson garden sprayer was used to saturate the leaf surfaces surrounding the test colonies with the spore suspensions. No determination was made of the amount of each suspension applied to the vines. Samples by count of living larvae per tagged colony were made on the first, third, fifth, and seventh days after application. The results are presented in table 2.

On the seventh day, the control populations showed a decline of 33 per cent below the level of the first day sample which was used for the base in the percentage mortality calculations in table 2. At the same time there was a 46 per cent drop in population in the colonies treated with the minimum concentration of spores, a decrease of 13 per cent below that of the control. The colonies treated with the two higher spore concentrations decreased in population from 70 to 75 per cent by the seventh day, about 40 per cent below that of the control.

Table 2.—Mortality of second- and third-instar *Harrisina brillians* larvae after spray applications of various concentrations of *Bacillus thuringiensis* spores. Fall 1954.[a]

Group	Spore Conc. Used (Grams/Gal.)	Percentage Mortality of Larvae on Days Following Application[b]		
		3	5	7
T-1	1	11	16	46
T-5	5	15	44	70
T-10	10	26	47	75
Control	0	4	14	33

[a] Average temperatures during test: Max. 86° F., Min. 53° F. (from U.S.D.C. Climatological Record, California Section, El Cajon 2-E Station, August 1954).
[b] Average of 4 colonies in T-1, 5 colonies in other groups.

In comparing the results of the two qualitative tests it is noted that the first test was conducted on first-instar larvae of an artificial infestation on wild grape, utilizing *B. thuringiensis* spore material produced early in 1952. The 1954 test was made against slightly older larvae of a natural infestation on cultivated grape utilizing spore material of the same 1952 vintage. The more rapid decline in the population of the untreated group of the 1952 test indicates that the artificially infested larvae may have been of lower vigor than those in the natural infestation. Although the age of the spore material, the size of the test larvae, and the slightly cooler temperatures may have had effects in extending the incubation period of the disease, the less effective control exhibited by the higher concentrations of spores in the 1954 test may represent a more accurate picture of the capabilities of the bacillus against the skeletonizer larvae.

With the knowledge that saturation of grape leaves with a *B. thuringiensis* spore suspension at a concentration of from 2 to 10 grams of spores per gallon of water will reduce the skeletonizer population by 40 to 70 percent, a test was undertaken to determine the effect of more limited amounts of infective material. This experiment was set up late in the season in the leased vineyard at El Cajon. At that time the second skeletonizer generation was past its peak and a third generation was starting. Thus the field population was made up of all stages of caterpillars from newly-hatched larvae in colonies to migratory mature individuals ready for pupation. There were indications that many of the larvae in the portion of the vineyard available for the test were infected with a granulosis virus.

A suspension of *B. thuringiensis* spores was blenderized and standardized at a concentration of 5 grams of dry spore powder per gallon of water. Four plots, each consisting of a row of vines 50 feet in length, were treated with the suspension applied by a Banta Hi-Fog sprayer (pressure 750 pounds per square inch) at the rate of 8.5 gallons per acre. Four similar plots were treated with the suspension applied by Hudson garden sprayer (pressure about 50 pounds per square inch) at the rate of 22 gallons per acre. Four 50-foot rows were left untreated.

Because of the make-up of the skeletonizer population, it was not possible to sample by colony counts as was done previously. The sampling method used consisted of counts of living larvae in each test and control replicate per 5 minutes of search. Counts were made on the day of application and on the third, sixth, twelfth, and nineteenth days thereafter. The results are presented in table 3.

Although after 3 days larval mortality in the test plots was much greater than in the checks, the overall results do not indicate that application of the bacillus has any effect on the skeletonizer population. Other factors including introduced insect parasites and the presence of the granulosis virus probably played major roles in bringing about the marked reduction in the populations of the test and control plots.

Table 3.—Effect of spray applications of limited amounts of *Bacillus thuringiensis* spores on mixed larval populations of *Harrisina brillians*. Fall 1954.[a]

Group	Method of Application	Appl. Rate Gal. per Acre	Percentage Mortality on Days Following Application[b]				
			0	3	6	12	19
T-1	Hi-Fog	8.5	0	29	43	80	84
T-2	Garden Sprayer	22	0	27	39	65	86
Control	—	—	0	2	27	70	87

[a] Average temperatures during test: Max. 87° F., Min. 50° F. (from U.S.D.C. Climatological Record, California Section, El Cajon 2-E station (August, September 1954).
[b] Average of 4 replicates in each group.

DISCUSSION AND SUMMARY.—Since the entomogenous sporeformer, *Bacillus thyringiensis*, was first observed and described by Berliner (1911, 1915), an increasing number of insect species have been found to be susceptible to the organism. Interest has continued over the years and recently several workers have reported on studies conducted in the laboratory and field to determine the value of *B. thuringiensis* as an agent of biological control (Steinhaus 1951, Hall 1954, McConnell & Cutkomp 1954).

The limited findings of Thompson and Logan indicating that the larvae of the western grapeleaf skeletonizer were susceptible to the Mattes' strain of the bacillus, gave rise to speculation on the possibilities of using the organism to control the pest. With the realization that the results of field trials rarely match those attained in the laboratory, the studies in the field were undertaken with the expectation that the mortality caused by the bacterium would be somewhat lower than the 83 per cent recorded by them. The results of the preliminary field test in 1952 were not considered to be too promising but suggestive that further studies should be made when suitable natural infestations of the skeletonizer become available.

Results of the 1954 qualitative test probably give a more significant picture of the ability of the bacillus to control the pest. The evidence that 25 to 30 per cent of the test larvae display resistance to *B. thuringiensis* when saturated with concentrated spore suspensions was a warning that the outcome of tests with less concentrated suspensions would be even less successful. The lack of effects from the second 1954 test was more likely due to the widespread presence of the granulosis virus, which, from the appearance of many of the colonies, was responsible for considerable mortality in both test and control plots. Additional tests against populations relatively free of virus infection would be of value, but it is doubtful if the percentage mortality attained with sprays of limited spore concentrations would be high enough to warrant recommendation of *Bacillus thuringiensis* as a biotic agent to replace insecticides in the control of the western grape leaf skeletonizer.

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Behavior of Pink Bollworm Larvae[1]

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During 1954 detailed observations were made on larval behavior of the pink bollworm, *Pectinophora gossypiella* (Saunders), as a part of the program of screening species and varieties of cotton for resistance to injury by this pest. Of the many interesting behavior characteristics noted, two were investigated in detail. First, pink bollworm larvae appear to be cannibalistic under crowded conditions. Second, larvae of the first instar move about over the host plant readily before entry into the fruit.

CANNIBALISM.—Ohlendorf (1926) stated that the mortality rate for pink bollworm larvae outside the cotton boll was over 90 per cent and was very low inside the boll. He based this statement on the discrepancy between the number of apparent entrance holes on the outside of the boll and the number of pink bollworm larvae actually found within the boll. Taylor (1936) reported pink bollworm larvae to be cannibalistic. In studies of plant resistance to the pink bollworm at College Station, green cottom bolls were infested with a known number of viable pink bollworm eggs. The eggs were counted and transferred to the boll with a moist camel's-hair brush. Ten to twelve days after infestation the bolls were examined and records made of entrance holes outside the carpel, entrance holes in the carpel lining and number of larvae recovered from each boll. These records indicate that approximately 90 per cent of the larvae attempting to enter the boll, as indicated by an entrance hole on the outside of the boll, were able to gain entrance. It was

[1] Accepted for publication April 7, 1955. Technical contribution No. 2179, Texas Agricultural Experiment Station in cooperation with Entomology Research Branch, Agricultural Research Service, U. S. Department of Agriculture. Thanks are due R. K. Williams for assistance in conducting this study.

Table 1.—Summary of tests comparing survival of pink bollworm larvae in bolls infested with a single egg or lots of 5 and 10 eggs at College Station, Texas, 1954.

Bolls Infested with Lots of Eggs as Indicated[a]							Bolls Infested with Single Egg[b]				
Date		No. Bolls	Eggs per Boll	Total Eggs	Entrance Holes	Larvae Recovered	No. Bolls	Loculi Infested	Total Eggs	Entrance Holes	Larvae Recovered
Infested	Examined										
6/10	6/21	5	5	25	13	5					
6/23	7/2	3	5	15	6	3					
6/30	7/9	5	5	25	10	6					
7/9	7/19	4	5	20	10	4					
7/9	7/19	5	10	50	14	7					
7/21	7/29	10	10	100	48	19					
7/26	8/5	6	10	60	24	6					
7/28	8/7	5	10	50	18	6					
8/5	8/16	5	10	50	27	8	9	31	31	16	16
8/11	8/22						5	19	19	7	7
8/13	8/23	5	10	50	27	7	6	24	24	17	16
8/16	8/26	4	10	40	18	9	6	19	19	15	15
8/20	8/31						4	12	12	9	9
8/30	9/9	12	10	120	72	21	12	48	48	36	34
9/12	9/23						6	22	22	19	18
9/20	9/30	10	10	100	51	18	12	48	48	32	28
Total		79		705	338	119	60	223	223	151	143
Per Cent Survival						35.0					95.0

[a] One lot of 5 or 10 eggs confined on 1 locule of each cotton boll.
[b] One egg confined on each locule of the cotton boll.

further noted that when two or more larvae entered the same locule of the cotton boll in the vicinity of each other generally only one larva would be recovered. These observations indicated that the larvae were cannibalistic and tests were conducted to determine this.

Methods.—Two rearing experiments were conducted. In the first experiment tin salve boxes 1 inch in diameter and 1 inch deep were filled about three-fourths with sand. A single cotton seed from which the outer coat was removed, was placed in each salve box on the sand. A few drops of water were added to the sand to keep the relative humidity high. Two second or third instar larvae were placed on the seed in each salve box and the box closed. Fresh food was added every 2 days at which interval the larvae were examined.

The second experiment was conducted by controlling the point of entry of the larvae into the cotton boll. Green cotton bolls that were used in this series of tests were 2 to 3 weeks old. The bolls were cut from the plant and each held with the stem in a bottle of water. These bolls were infested with viable pink bollworm eggs as follows: One group of bolls was infested by transferring a single egg with a camel's-hair brush to each locule of the boll. A No. 00 gelatin capsule was placed over each egg and attached to the boll by means of warm paraffin. By this procedure only one larva could enter each locule of the boll. Another group of bolls was infested by transferring lots of 5 or 10 viable pink bollworm eggs to only 1 locule of each boll. These lots of eggs were isolated on a small area of the boll as described above for the single egg. In this case all the larvae were forced to enter the boll in a small area of one locule of the boll. There should have been adequate food in the remainder of the boll for all larvae that gained entrance. The number of tests conducted and the date of each are shown in table 1.

Results.—When two larvae were confined on a single cotton seed they were observed for a period of time to see if they actually attacked each other. The larvae would crawl about over the cotton seed, apparently in an attempt to escape the light, and try to web themselves underneath the seed. They avoided each other as much as possible but when they could not, because of limited space, they attacked each other. When a larva was injured, it would stop fighting and usually crawl away from the food. The uninjured larvae would frequently crawl over injured larvae but were not observed to actually feed on them.

In this test 10 larvae were placed singly in boxes and used as a check. All 10 individuals reached the pupal stage. In 40 boxes with 2 larvae each, 42 pupae were recovered, 1 from each container except 2 in which both larvae reached the pupal stage.

The results of the tests in which the point of entry of the larvae was controlled are shown in table 1. A striking difference is evident when the percentage of larvae recovered from bolls infested with a group of eggs is compared with the percentage recovered from bolls infested with a single egg per locule. When eggs were confined in lots of 5 or 10 on a locule of the boll, 48 per cent of the possible larvae effected entrance and only 35 per cent of these were recovered. In the case of a single egg confined to the locule, 68 per cent of the possible larvae entered and 95 per cent of these were recovered. These results indicate that pink bollworm larvae are extremely antagonistic and that many are killed when they come in contact with each other under crowded conditions inside the cotton boll.

Migration.—Ohlendorf (1926) found that the position of the pink bollworm egg on the cotton plant had little effect on the number of larvae recovered from the cotton fruit. It was observed early in this study that when cotton bolls were artificially infested with a compact group of pink bollworm eggs, the entrance holes of the larvae were well scattered over the entire boll. Frequently after certain bolls of a specific plant had been infested, blooms were subsequently found to be infested on this plant. In

such cases hatching larvae must have migrated from infested bolls that were infested with the eggs to uninfested squares. This indicated that pink bollworm larvae will migrate over the host plant before entering the fruit. This larval habit was investigated to determine the extent of migration and survival of these larvae.

Methods.—In the greenhouse, cotton squares about 1 week old were infested by transferring pink bollworm eggs to them with a moist camel's-hair brush. Pink bollworm eggs were selected that had developed sufficiently to hatch within 24 hours of infestation. The squares were left on the cotton plant until time for examination. Ten squares were infested with 1 egg each and the test was replicated 4 times. Ten squares were infested with 5 eggs each and this test was repeated 3 times. The tests were conducted simultaneously except for the first 10 squares infested with 1 egg each. The squares were examined 3 to 5 days after infestation and records made of eggs hatched, number of entrance holes in the squares and number of larvae recovered.

Another test was conducted in the greenhouse to determine the survival of these migrating larvae. Ten potted cotton plants were selected that had 10 to 15 squares each. Five plants were infested by transferring 10 viable pink bollworm eggs to 1 tagged square of each plant with a moist camel's-hair brush. The other five plants were infested in the same manner except that the eggs were placed on a centrally located leaf on each plant. One week later all squares and bolls were examined for larvae. This same procedure was followed in another test conducted in the field using 10 caged cotton plants.

Results.—Forty cotton squares that were infested with one egg per square were examined. Thirty-three eggs hatched, 28 entrance holes were found and 28 larvae were recovered. In this experiment approximately 85 per cent of the hatched larvae entered the infested squares. Thirty squares were infested with five eggs per square. Examination showed that 135 of these eggs hatched, 40 larval entrance holes were counted and 32 larvae were recovered. These 40 entrance holes represent approximately 30 per cent of the number of larvae that hatched on the infested squares. When the squares were infested with 5 eggs, generally only 1 larva would enter the square. Apparently the small size of the cotton square and the unsocial nature of the larvae are the causes of the extensive migration away from infested squares.

These results indicate that first instar pink bollworm larvae move about over the fruit after hatching and if the fruit is small, as in the case of the cotton square, they encounter each other frequently. Because of their irritability toward each other, many leave the infested fruit to seek food elsewhere. In fact, the larvae have been observed moving about over the vegetative parts of the cotton plant after only the fruit had been infested. When the larvae encounter each other there is an immediate rapid avoiding reaction.

Table 2.—Percentages of pink bollworm larvae surviving when egg masses were placed on squares and leaves of the cotton plant at College Station, Texas, 1954.

	In Greenhouse[a]			In Field[a]		
	Squares Examined	Larvae Recovered	Per Cent Survival	Squares Examined	Larvae Recovered	Per Cent Survival
5 squares infested	56	18	36	69	13	26
5 leaves infested	47	11	21	146	21	42

[a] Five plants infested with 10 eggs per plant in each category.

Results of the tests conducted in the greenhouse and field to determine the rate of survival of migrating larvae are shown in table 2. These results indicate that relatively large numbers of these migrating larvae survive, particularly if there is an abundance of fruit on the cotton plant.

SUMMARY.—Studies of the behavior of pink bollworm larvae were conducted during 1954 at College Station as a part of studies of host plant resistance to the pink bollworm. These studies revealed that pink bollworm larvae attack and kill each other under crowded conditions inside the cotton boll. Although first instar larvae were not observed to attack each other, they exhibited marked antagonism toward each other and moved about over the plant readily under crowded conditions. A relatively large percentage of these migrating larvae were able to find other fruits and establish themselves.

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TENTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

Montreal, Canada,
August 17–25, 1956.

The Relative Toxicity to House Flies of Pirazinon, Am. Cyanamid 4124, and Malathion in Comparison with Parathion and Pyrethrins[1]

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A study has been made of the relative toxicity of three organic phosphorus compounds—Pirazinon, Am. Cyanamid 4124, and malathion—with the house fly, *Musca domestica* L., as the test insect. The first two compounds are new candidates for use as insecticides. Pirazinon is closely related to Diazinon, possessing the *n*-propyl instead of the isopropyl group, and 4124 is the orthochloro derivative of methyl parathion. Malathion has been used for several years.

MATERIALS.—The samples of these compounds used were of technical grade. However, their purity was high—90 per cent for Pirazinon, 97 per cent for Am. Cyanamid 4124, and 95 per cent for malathion. Only if nearly all the impurities were of relatively high toxicity, an unlikely possibility, would the evaluations of a bioassay be materially affected.

The samples of Pirazinon and malathion were brownish liquids; that of 4124 was a white crystalline solid. They all formed clear solutions at a concentration of 10 mg. per milliliter of refined kerosene, Pirazinon, however, only after the settling of a negligible amount of fine brownish material.

Parathion and pyrethrins were used as standards of comparison, the former because of its chemical relationship and the latter because of its long-time use as a standard for house fly sprays. The sample of parathion was pure; the pyrethrins were those contained in the complete extractives of pyrethrum flowers without further processing, 61 per cent consisting of pyrethrin I and cinerin I as determined by the mercury-reduction method. Stock solutions of the standards were also prepared in kerosene.

PROCEDURE.—After preliminary tests, sprays were prepared by diluting aliquots of the stock solutions with refined kerosene to concentrations selected to cause a range of mortalities from high to low.

Knockdown and mortality of laboratory-reared house flies treated with these sprays were determined by the Campbell turntable method. All sprays were tested simultaneously on each of six populations of flies. Approximately 107 flies 2–3 days old were used in each test.

To evaluate relative toxicity and determine the precission of the estimates, the mortality data were subjected to probit analysis as described by Finney (1952).

KNOCKDOWN AND MORTALITY.—All but two of the organic phosphorus sprays caused practically no knockdown of flies in 25 minutes. Malathion caused 12 and 10 per cent knockdown at the highest two concentrations. Pyrethrins, as is usual at the concentrations used, caused complete knockdown.

The mortality data are summarized in table 1.

EVALUATION OF RELATIVE TOXICITY.—Provisional regression lines were fitted graphically to the mortality data. The statistical procedure was followed for the individual lines of pyrethrins and malathion and for generalized lines of the other three compounds. The final equations, showing the regression of mortality, expressed in probits, on concentration in milligrams per deciliter, expressed as logarithms, are given below. Standard errors of the regression coefficients (b) are also given.

Table 1.—Relative toxicity to house flies of malathion, Pirazinon, and Am. Cyanamid 4124 in comparison with parathion and pyrethrins.

COMPOUND AND CONCENTRATION	MORTALITY IN 1 DAY	LC-50	TOXICITY RELATIVE TO—	
			Parathion	Pyrethrins
Mg. per dl.	*Per Cent*	*Mg. per dl.*		
Malathion				
225	94.3			
169	85.3			
126	64.0	111.24 ±1.13	0.0616±0.0009	2.060±0.048
94.8	36.8			
71.1	11.7			
53.3	3.2			
Pirazinon				
40.0	97.9			
30.0	91.3			
22.5	70.5	18.79 ±0.18	0.3648±0.0048	12.19 ±0.28
16.9	41.6			
12.7	10.8			
9.49	1.3			
Am Cyanamid 4124				
22.5	96.0			
16.9	85.2			
12.7	60.4	11.44 ±0.11	0.5986±0.0081	20.03 ±0.47
9.49	33.3			
7.12	9.3			
Parathion				
13.33	97.9			
10.00	84.6			
7.50	59.0	6.854±0.064	1.0	33.43 ±0.77
5.63	30.7			
4.22	7.7			
3.16	1.6			
Pyrethrins				
759	89.5			
506	81.3			
338	66.3	229.1 ±4.8	0.0299±0.0007	1.0
225	50.9			
150	33.5			
100	16.0			

		Standard error of b
Malathion	$Y=5.6620\ X-6.5860$	0.15
Pirazinon	$Y=6.4620\ X-3.2323$	.10
Am. Cyanamid 4124	$Y=6.4620\ X-1.8419$	.10
Parathion	$Y=6.4620\ X-0.4020$	.10
Pyrethrins	$Y=2.5132\ X-0.9312$	.08

From these equations the median lethal concentrations (LC-50's) were calculated. Relative toxicities were calculated as the inverse ratio of the relevant pair of LC-50's The estimations together with their standard errors are given in table 1. Heterogeneity factors were not required. The six populations of flies were remarkably homogeneous, and the fit of the lines to the data was very good, as reflected in the unusually low errors.

DISCUSSION.—Am. Cyanamid 4124, has thus been shown to be the most toxic to house flies of these three phosphorus compounds, being 0.60 as toxic as parathion. Since the methyl homolog of parathion was found to be 0.68 as toxic as parathion by this method (Gersdorff &

[1] Accepted for publication April 8, 1955.

Mitlin 1951), the conclusion is reached that the substitution of hydrogen for the chlorine atom in the 4124 molecule increases the toxicity about 13 per cent.

Am. Cyanamid 4124 was about 20 times as toxic as pyrethrins.

Pirazinon was 0.36 as toxic as parathion and therefore less toxic than its isopropyl isomer, Diazinon, which has been found 0.51 as toxic as parathion by this method (Gersdorff *et al.* 1954). Despite the difference in purity of the two technical products, 90 per cent for Pirazinon and 95 per cent for Diazinon, unless nearly all the impurities are relatively high in toxicity, which is unlikely, it may be deduced that the substitution of the isopropyl group for the *n*-propyl group in the Pirazinon molecule is accompanied by an increase in toxicity of about 33 per cent.

Pirazinon was about 12 times as toxic as pyrethrins.

Malathion was by far the least toxic of the four phosphorus compounds, being only 0.062 as toxic as parathion. However, since its relative toxicity was twice that of pyrethrins it is still a potent insecticide.

The ratio of toxicity of parathion to pyrethrins, 33 to 1, is the lowest obtained in several comparisons of the two by this method, the others being 40 (Gersdorff & Nelson 1948), 70 (Gersdorff & Mitlin 1950[2]), and 61 (Gersdorff *et al.* 1954). All ratios except the present one were from comparisons with pyrethrins containing 52 to 53 per cent of pyrethrin I and cinerin I. Since the sample of pyrethrins used in this study contained 61 per cent of these compounds and they are more toxic than the corresponding type II compounds (Gersdorff 1947), this sample should be more toxic. However, its higher toxicity cannot account for a substantial difference in the ratio, for it can be deduced from the work cited that the increase should be only about one-tenth. This deduction has been experimentally corroborated by the finding of a mean ratio of toxicity of 2.5 for allethrin when compared with the 61 per cent standard as against 2.75 in a number of comparisons with the 52 per cent standard. It is therefore probable that the unusually great variation in ratios is due to the different effects of the slightly varying conditions unavoidable in extensive biosassays on the response of the flies to such chemically dissimilar toxicants. Especially wide variation in toxic ratio may then be expected from regression lines with such divergent slopes.

SUMMARY.—The relative toxicities to house flies, *Musca domestica* L., of the organic phosphorus compounds Pirazinon, Am. Cyanamid 4124, and malathion in comparison with parathion and pyrethrins were determined by the Campbell turntable method. The three compounds were, respectively, 0.36, 0.60, and 0.062 as toxic as parathion and 12, 20, and 2 times as toxic as pyrethrins.

At the concentrations used these phosphorus compounds caused no, or negligible, knockdown of flies in 25 minutes.

Two conclusions were made with respect to the relationship of chemical structure and toxicity: The substitution of the isopropyl group (forming Diazinon) for the *n*-propyl group in the Pirazinon molecule increases the toxicity by about 33 per cent, and the substitution of hydrogen (forming methyl parathion) for the chlorine atom in the Am. Cyanamid 4124 molecule increases the toxicity by about 13 per cent.

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[2] The LC-50 of parathion should read 0.0438 instead of 0.0483.

Biological Control of the Orange Spiny Whitefly in Guam[1]

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The orange spiny whitefly, *Aleurocanthus spiniferus* (Quaint.), was first recorded from Guam in June, 1951 by the author. Following its discovery it spread rapidly to all parts of the Island except the northern end and soon became a serious pest of citrus. It was not recorded from the northern portion of the Island until late in 1953. The northern half of Guam contains large areas still covered by remnants of the original jungle. Where the land has been extensively cleared, several large military bases have been constructed. Consequently, there is little host material available to the aleyrodid except in isolated sections. The distances separating these plantings inhibited the natural spread of the pest from the central and southern portions of the Island. In central and southern Guam conditions greatly favored the rapid spread of the pest. This is the most densely populated part of the Island and there are numerous dooryard and small farm plantings of the favored host plants. Cuttings and seedlings of these plants are frequently transported from one area to another. This movement of host material was important in the spread of the aleyrodid. *A. spiniferus* attacks all varieties of citrus in Guam. Infestations of the so-called

[1] Accepted for publication April 11, 1955.

"Chinese lemon," a variety of lime, are rare, however, and extremely light. The aleyrodid also infests rose, grape, and flowering peach, apple, and pear.

The mild temperatures and relative high humidity which prevail in Guam provide near ideal conditions for the development of *A. spiniferus*. In most localities there are five generations each year. Under optimum conditions six generations are not uncommon whereas under insectary conditions seven generations have been produced. The annual dry period which occurs during the spring months retards development in open areas. Where topographical and other factors combine to produce a higher humidity this effect is not so noticeable. During periods of extreme weather conditions high mortality occurs in the different stages. A severe dry spell causes a high mortality in the egg stage. Reduced humidity and rainfall result primarily in a marked mortality in the early larval stages and in the pupal stage. The heavy, driving rains which are common during the wet season cause the death of large numbers of females by washing them from the foliage. High winds of long duration, as during typhoons, prevent feeding and oviposition and also carry the females away from host plants suitable for oviposition.

A. spiniferus probably was introduced into Guam from the Orient on infested host plants imported into the Island. The species is common in Japan and the coastal areas of China and it also occurs in the Philippines, Dutch East Indies, and India. Air and surface traffic into Guam from Manila and Tokyo has been heavy since World War II and many importations of rose and citrus plants are known to have been made by local island residents and by Americans temporarily residing in Guam.

The fact that most of the citrus grown in Guam consists of small, scattered plantings makes it difficult to apply chemical control methods for the suppression of insect pests. This difficulty is enhanced by the Guamanian farmer's tendency to plant irregularly on very uneven terrain and to underplant the trees haphazardly with other food crops. In those areas where insecticides can be applied the cost is so high that it is not warranted by the market value of the fruit produced. Although much of the fruit is of inferior quality, citrus production is important in the subsistence agriculture of the Island. These factors served to emphasize the need for an efficient biological control of *A. spiniferus*.

BIOLOGICAL CONTROL.—Biological control of the orange spiny whitefly was initiated in the spring of 1952. On April 10 the first shipment of parasites was received from Mexico through the cooperation of Herbert D. Smith, entomologist with the former Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. He was cooperating with the Mexican National Committee for the Combat and Control of Citrus Blackfly in collecting and distributing several species of parasites which had been introduced into Mexico from India in 1950 in an attempt to control the citrus blackfly, *Aleurocanthus woglumi* Ashby. Three additional shipments were received from Mexico during the summer of 1952, the last arriving in Guam on October 19. The following species of parasites were included in these shipments: *Prospaltella smithi* Silv., *Prospaltella clypealis* Silv., *Prospaltella opulenta* Silv., *Eretmocerus serius* Silv., and *Amitus hesperidum* Silv. All parasites were shipped in the adult stage except *A. hesperidum*. This species was shipped in its host pupae, *Aleurocanthus woglumi*, on orange leaves as it does not survive well when shipped in the adult stage. Shipments were by air express and the average time in transit from Mexico City to Agana, Guam was 6 days. The adult parasites were shipped in glass tubes about 3.75 inches long by 0.44 inch in diameter, 100 parasites per tube. The tubes were closed with corks which were perforated, the holes being covered with tightly woven cloth. A strip of blotting paper saturated with pure honey was placed in each tube to provide food. The tubes were grouped in bundles, wrapped in cotton to prevent breakage, and packed in corrugated pasteboard boxes approximately 1 foot square provided with screened ventilating holes. Slightly dampened sphagnum moss was used as packing material in addition to the cotton. Two consignments of *Amitus hesperidum* material were received. Both were included with shipments of adults of the other species of parasites and were shipped in the same containers. The orange leaves bearing the parasitized *Aleurocanthus woglumi* pupae were shipped in paper or pliofilm sacks which were closed with rubber bands and enclosed in strong, tightly woven cloth bags. Mortality during transit varied considerably with the species and ranged from about 2 to 95 per cent. From these shipments the following adult parasites were received alive and liberated: 17,000 *P. smithi;* 30 *P. clypealis;* 88 *P. opulenta;* and 13,500 *E. serius*. A total of 28,100 *Amitus hesperidum* adults were reared from the two shipments and liberated. Since *Aleurocanthus woglumi* does not occur in Guam, the material containing *Amitus hesperidum* was held in quarantine during the emergence of this parasite. Smith's observations in Mexico indicate that no *Aleurocanthus woglumi* adults emerge from pupae after 11 days from date of collection of host leaves. Only two *A. woglumi* adults emerged, both from the second shipment. All shipments were unusually clean and free from extraneous insect or plant inclusions.

When the shipments of *Amitus hesperidum* material arrived at the laboratory the outer cloth sacks were removed. The ends of the inner sacks were then inserted into large (2000 ml.) Erlenmeyer flasks and the leaves shaken out. Care was taken to insure that no insects escaped. Each flask was then closed by means of a heavy cardboard disk which completely covered the open end of the flask and was securely taped to the glass. A small, perfectly round hole was cut in the center of the disk into which was inserted one of the glass tubes used in shipping adult parasites. The bases of the flasks were darkened and as the parasites issued they readily moved upward into the tubes. It was then a simple matter to count the parasites and check for the presence of possible *Aleurocanthus woglumi* adults or other insects. The parasites were allowed to feed for several hours on honey then were taken into the field and liberated. *Amitus hesperidum* emerged daily over a period of nearly 6 weeks.

Of the five species introduced only *P. smithi* and *A. hesperidum* are known to be definitely established. *E. serius* was recovered on several occasions during 1953, but has not been recovered since then. It is possible that the pronounced dry season which occurs in Guam each spring is responsible for the failure of *E. serius* to become

established. Smith (1951) reports its inability to work effectively during similar long dry periods in Mexico. *P. dypealis* and *P. opulenta* have never been recovered. *P. smithi* and *Amitus hesperidum* are both well established and are successfully controlling *Aleurocanthus spiniferus* throughout the Island. Parasitism by the two species varies from 80 to 95 per cent on citrus with *P. smithi* predominating. About 65 per cent of parasitized host pupae produce *P. smithi* adults. Nearly all citrus plantings are now nearly free of *Aleurocanthus spiniferus*. There is a noticeable improvement in the condition of the citrus trees and increase in yield of fruit.

It is interesting to note that the parasites have not been able to reduce infestations on rose and grape plants as spectacularly as in the case of other hosts of the orange spiny whitefly. Many rose and grape plantings throughout Guam continue to be heavily infested and to suffer considerable damage. Smith (1951) reports a similar situation in Assam, India in which parasitism of *Aleurocanthus spiniferus* on rose bushes by *P. smithi* never exceeded 20 per cent.

SUMMARY.—The orange spiny whitefly, *Aleurocanthus spiniferus* (Quaint.) formerly was a serious pest of citrus and other plants in Guam. Five species of parasites were introduced from Mexico in 1952. Two of these species, *Prospaltella smithi* and *Amitus hesperidum*, became established. Parasitism by the two species varies from 80 to 95 per cent with *Prospaltella smithi* predominating. Commercial control of the orange spiny whitefly by parasites has been achieved.

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Biological Control of the European Corn Borer on Guam[1]

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The European corn borer, *Pyrausta nubilalis* (Hbn.), was first recorded from Guam in 1911 by Fullaway (1912) under the name *Pyrausta vastatrix* Schultze, a name which was later recognized as a synonym. The corn borer rapidly assumed the status of a very serious pest on Guam and by 1920 was reported damaging 50 per cent of the corn crop in some parts of the Island.

Attempts at biological control of the corn borer on Guam were made during the years 1926 to 1932 during which period the following parasites were introduced: *Exeristes roborator* (Fabr.); *Zaleptopygus flavo-orbitalis* (Cameron) = (*Cremastus flavo-orbitalis* (Cameron)); *Eulimneria* sp.; and *Lydella stabulans grisescens* R. D.

Vandenberg (1928), then entomologist for the Guam Agricultural Experiment Station,[2] records that two shipments of corn borer material containing the parasite, *E. roborator*, were received from the laboratory of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture at Arlington, Massachusetts during 1926. From the first lot he succeeded in rearing only one female and four males, and from the second shipment 42 females and 53 males were liberated on Guam. Attempts to breed this parasite were only partly successful in that only males were obtained, indicating that the females had not been properly fertilized.

On November 24, 1927, a consignment of *E. roborator* consisting of 1771 cocoons was received from the corn borer laboratory of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture at Monroe, Michigan. This material was shipped by boat in cold storage and arrived in good condition. According to Vandenberg (1930), a total of 1083 parasites comprising 467 males and 612 females were successfully reared and liberated in the Barrigada and Dededo districts. Twenty females and ten males were retained for breeding stock in the insectary and these were augmented by late-emerging parasites from the original shipment. Attempts to breed the parasite were successful and thousands of adults of this species were reared and liberated during the next few years. Efforts to establish this parasite failed, however, and only one pupa was recovered from which a female emerged. Vandenberg (1930, 1931) gives a good account of the difficulties encountered in the laboratory propagation of this parasite on Guam. The excessive mortality due to various fungus diseases of the host larvae in the insectary could never be fully controlled.

In 1930 Vandenberg (1933) went to Japan where he collected 12,000 corn borer larvae, which were shipped to Guam in cold storage at temperatures ranging from 30° to 40° F. From these larvae, 1071 adults and 394 pupae of *L. stabulans grisescens*, 141 adults of *Z. flavo-orbitalis*, and 25 adults of *Eulimneria* sp. were reared. In addition, 40 adults of *Eulimneria* sp. issued from 50 cocoons which were also included in the shipment. Part of the *Z. flavo-orbitalis* and most of the *Eulimneria* sp. were used in an unsuccessful attempt to breed the two species; the remainder were liberated. Laboratory breeding of *L. stabulans grisescens*, on the other hand, was highly successful and by June, 1932, many thousands had been reared and released throughout the Island. Vandenberg does not mention whether *Z. flavo-orbitalis* or *Eulimneria* sp. ever became established. Swezey (1946) records that he reared *Z. flavo-orbitalis* from several species of leafroller moths, but none from the corn borer.

L. stabulans grisescens became established and rapidly

[1] Accepted for publication April 11, 1955.

[2] The Guam Agricultural Experiment Station was closed in 1932, reopened by the Naval Government of Guam in 1933 and operated as an agriculture school until the Japanese invasion in December, 1941. It was completely destroyed during the reoccupation of Guam by American forces in 1944.

reduced the corn borer to low population densities. Vandenberg (1933) reports: "It appears to be a very efficient parasite . . . approaching the danger point of self-extermination in the most favorable locations." Swezey (1946) reports that when he visited Guam in 1936 he found *L. stabulans grisescens* so efficient that "very little damage was done to the corn crop by the European corn borer. Whenever we found corn borer larvae in corn stalks, usually 50 to 100 per cent of them were parasitized."

In 1951, when the author assumed the duties of entomologist in the Guam Department of Agriculture, the corn borer was causing very serious damage to the corn crop. The amount of corn seriously damaged or destroyed in that year varied from 50 to 85 per cent in various parts of the Island. During 1951 a survey was made of corn fields and several thousand corn borer larvae were collected in the field and placed in the insectary for parasite emergence. Only a single pupa of *L. stabulans grisescens* was recovered from this material and no other parasites were reared, collected, or observed in the field. For reasons unknown *L. stabulans grisescens* was not able to maintain its high degree of effectiveness in controlling the corn borer on Guam.

A further attempt at biological control of the corn borer on Guam was made in 1952. In the fall of 1951, the Moorestown, New Jersey corn borer laboratory of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture was asked to collect corn borer larvae for shipment to Guam. On February 21, 1952 a consignment consisting of 32,400 field collected larvae was received. The larvae were shipped in the dormant state and during transit were kept in the ship's fruit and vegetable chamber at about 38° F. Upon arrival in Guam they were placed in cold storage at approximately 36° F. and 85 per cent humidity.

The larvae were removed from cold storage on April 8, passed through a preliminary warm-up period of about 24 hours duration, and placed in emergence cages in the insectary. They were not disturbed during the cold storage period. Parasites were handled only once between emergence and liberation, thus reducing mortality to a minimum. Issuance of parasites was disappointingly low for two reasons: (1) the request for material was received at Moorestown too late in the season to permit collection of larvae in fields known to contain a fairly high degree of parasitism; and (2) a fungus disease developed among the larvae during rearing due to the impossibility of controlling the temperature and humidity in the insectary, thus causing the death of thousands of host larvae. From this material the following parasites were reared: *Macrocentrus gifuensis* Ashm.—3105; *Horogenes punctorius* (Roman)—142; *L. stabulans grisescens*—511; and *Chelonus annulipes* Wesm.—319.

These parasites were liberated at Agat, Yigo, Machanao, and Merizo. Liberations were made during April, May, and June. In July, several weeks after liberation, several *L. stabulans grisescens* adults issued from corn borer larvae collected near the release site at Agat. The same tachinid was recovered a second time from the same area in August. Absence of the entomologist from the Island on official business for several months, and pressure of other work on his assistants prevented further collection of corn borer larvae for parasite rearing or field surveying for adult parasites during the balance of 1952.

In December, 1952, the author discussed Guam's corn borer problem with entomologists at the Moorestown corn borer laboratory and it was decided that an additional large shipment of corn borer larvae to Guam would be in order. This proposal was approved by the Government of Guam and delivery of 50,000 corn borer larvae was contracted for on September 8, 1953. This second shipment of larvae from New Jersey arrived in Guam on February 24, 1954. It was shipped in the same manner as the previous shipment, and received the same treatment after arrival in Guam. In an effort to avoid a repetition of the disease-produced mortality which caused such a loss in the previous shipment, the larvae were packed in a different manner. In the 1952 shipment the larvae were permitted to spin up in long, folded strips of newspaper in paper ice cream cartons while in the 1954 shipment, the larvae were allowed to spin up between short strips of corrugated pasteboard held together with rubber bands in packets approximately $4\frac{1}{2}$ inches square by $\frac{3}{4}$ inch in depth. In order to reduce excessive mortality among the larvae due to disease, it was decided to incubate the larvae in relatively small lots at regular intervals. One such incubation was underway when the walk-in refrigerator in which the rest of the larvae were being held ceased operating on a week-end due to mechanical failure. When discovered, all larvae were active and migrating and it became necessary to rear the entire shipment immediately. Again fungus disease took a heavy toll. Emergence of moths approximated 10 per cent.

From this second consignment the following 6651 parasites were reared: *M. gifuensis*—3614; *H. punctorius*—159; *C. annulipes*—2774; *L. stabulans grisescens*—98; *Agathis agilis* (Cresson)—6. These were liberated at Yigo, Agat, and Merizo during April and May, the only areas where corn borer infestations were favorable for liberation. Due to the failure of cold storage facilities, the parasites emerged prematurely and were released at an unfavorable time when very few host eggs and suitable larvae were available in the field. No recoveries of parasites have been made since the 1954 liberations and there is no evidence that any of these parasites have become established. The disappearance of *L. stabulans grisescens* which a few years ago was a very efficient parasite of the corn borer cannot be satisfactorily explained.

SUMMARY.—The European corn borer, *Pyrausta nubilalis*, was first recorded from Guam in 1911 where it soon became a pest of major importance. During the years 1926 to 1932 several parasites were introduced from the United States and Japan. One species, *Lydella stabulans grisescens*, became established and for a number of years successfully controlled the corn borer, then seemed to disappear. Further introductions of parasites from the United States were made in 1952 and 1954, but there is little evidence that any parasites have become established. Factors responsible for the disappearance of *L. stabulans grisescens* are not known.

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Further Studies on Control of Potato Aphid on Tomatoes[1]

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Although the potato aphid, *Macrosiphum solanifolii* (Ashm.), is primarily a pest of potato, it sometimes becomes sufficiently abundant to be of economic importance on tomato. Within the period of 1917 to 1954 there appeared at least three publications that describe serious outbreaks of the potato aphid on tomatoes, Houser *et al.* (1917), Smith (1919), and Taschenberg (1949).

The project on aphid control on tomatoes in western New York was initiated in 1946. The objects of the investigation were: to evaluate recently developed insecticides as aphicides, and to determine the weathering rate of spray residues of the more promising materials. An earlier report by the senior author (1949) includes results from studies made in 1946, '47 and '48. Herein are presented observations on aphid activity in 1952 and results from control experiments conducted during 1951 and 1952.

BIOLOGICAL OBSERVATIONS.—The most recent severe outbreak of aphids to occur on tomatoes in western New York was in 1946. Populations were lower in 1947 and except in a few fields failed to reach serious proportions any year thereafter until 1952. During 1952 the infestation was severe again, and occurred between the time fruit began to ripen and the peak of harvest.

The buildup of aphid populations tends to follow a rather definite pattern. Some few individuals are usually present in tomato plantings by late June or early July. By mid-July a definite increase occurs, and between this time and the middle of August the infestation usually reaches a peak and declines. Aphid activity varied from that usual pattern in 1952. General observations on July 25 revealed the presence of a very small population. Between this date and mid-August a gradual increase was noted. Thereafter, the infestation became more severe and remained at a high level throughout most of September. Information on abundance of the pest on untreated check plots in late August and September is given in table 2.

During 1952 observations were made on aphid populations on the varieties Long Red, Peron, Queens and Valiant grown in replicated plots in the same block. For the determination of populations a total of 40 terminals were examined from each variety. The sample was composed of four lots of 10 terminals each, selected at random. Only two terminals were taken from a plant. Information on the buildup of aphid population over an 8-day period on four varieties of tomatoes is presented graphically in Fig. 1.

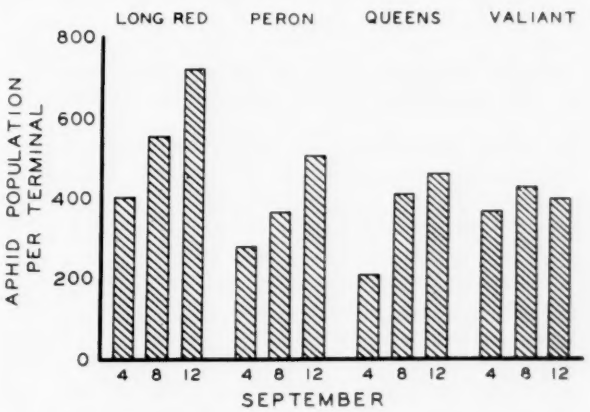

FIG. 1.—Increase in aphid population on four varieties of tomatoes during an 8-day period.

As may be seen, Long Red, an important commercial variety in western New York, bore the greatest number of aphids. When the initial aphid count was made the populations on Long Red and Valiant were similar. After an 8-day period there was a marked increase in the infestation on Long Red, whereas on Valiant the number of aphids remained approximately the same. The Valiant vines have long runners and light foliage. Plants of Long Red are of medium size with abundant foliage and the leaves and leaflets are small and finely divided. While the populations were larger on Long Red, it is unlikely that they were more injurious owing to growth density differences in the two varieties.

CONTROL EXPERIMENTS.—During 1951 control investigations were conducted in five plantings. This was necessitated when the infestation level needed for test purposes was concentrated in only a section of a planting. Because of this situation no treatment was replicated within the same block. Instead, similar treatments were repeated in two or more plantings.

In 1952 the experiments were carried out in two blocks located in the same planting. When the experiments were outlined the plan was to make a second application of all treatments. Unfortunately, this was not accomplished due to adverse conditions for the operation of the sprayer. Although the experiment was not carried out as planned,

[1] Journal Paper No. 1000, New York State Agricultural Experiment Station, Geneva, N. Y., April 7, 1955. Accepted for publication April 13, 1955.

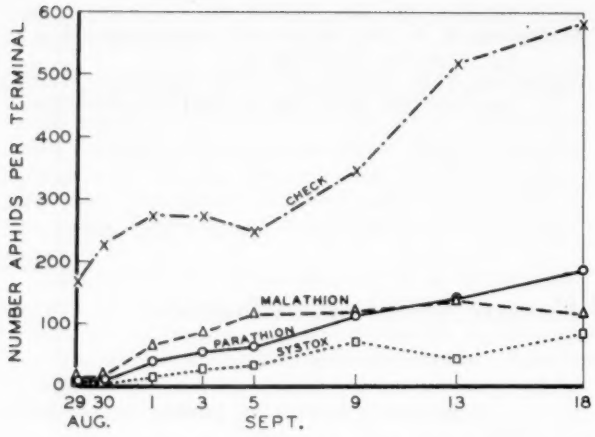

FIG. 2.—Graphic presentation of results with the emulsifiable preparations of Systox, parathion and malathion.

the results are reported here since the potentialities of the materials were rather clearly revealed. The rate of infestation in one area (approximately 6 acres) of the tomato field was severe and in the other (about 4 acres) there was a moderate and uniform infestation.

Evaluations were made on seven organic phosphorous insecticides. Both wettable powder and emulsifiable formulation of several materials were included. All insecticides were applied as sprays with a hydraulic sprayer and a flexible pendant type boom. The rate per acre was 200 gallons and the pressure was 400 pounds per square inch. The boom was equipped with 5 nozzles per row. One nozzle directed spray downward on the plants, and the pendants carried along each side of the row of vines two nozzles, angled to deliver spray in an upward direction beneath the leaves. Each nozzle was fitted with a disc having a 3/64 inch aperture and a three-hole whirl plate. The pendant boom is preferred over an overhead boom in combatting aphids as it gives more complete coverage of the vines.

Counts to determine aphid populations on treated and untreated plants were made on samples of compound leaves or terminals of from 3 to 4 inches in length. The part of the plant selected for this purpose depended on the general location of aphids at time treatments were applied. Each sample from a plot was composed of either 20 leaves or a like number of terminals. These were picked at random from every fifth plant in the center row or rows of the plot. The manner in which samples were handled at time of collection and the procedure followed to determine the aphid population are described in papers by Hartzell & Horsfall (1944) and Taschenberg (1949).

The insecticides tested and results obtained during 1951 and 1952 are given in tables 1 and 2. The data in table 2 along with data from additional counts on treatments with several wettable powders or emulsifiable formulations are presented graphically in Figs. 2 and 3. In all experiments parathion at the 1 to 100 rate served as the standard of comparison. When combined with 8-4-100 bordeaux the effectiveness of parathion was only slightly decreased. The material EPN which has received relatively little attention as an aphicide proved to be

Table 1.—Aphicidal efficiency of several organic phosphorous insecticides. 1951.

Formulation[a] and Date Treated	Pounds per 100 Gals.	Aphid Population on Dates Indicated			
Test 1[b]					
7/20		*7/21*	*7/23*	*7/25*	*7/27*
		(Per compound leaf)			
25% malathion (w.p.)	1.0	28	23	25	19
25% malathion (w.p.)	2.0	23	5	5	3
15% parathion (w.p.)	1.0	13	2	1	1
Untreated		59	55	90	87
Test 2[c]					
7/31		*8/2*	*8/4*	*8/6*	*8/9*
		(Per compound leaf)			
27% EPN (w.p.)	1.0	4	1	1	1
15% parathion (w.p.)	1.0	4	1	1	1
Untreated		70	125	106	92
Test 3[d]					
8/1		*8/3*	*8/5*	*8/8*	
		(Per compound leaf)			
15% parathion (w.p.)	1.0	5	1	3	
15% parathion (w.p.) + Bordeaux 8-4-100	1.0	3	1	5	
Untreated		155	90	125	
Test 4[e]					
8/1		*8/3*	*8/5*	*8/8*	*8/9*
		(Per terminal)			
25% malathion (w.p.)	1.5	14	22	17	16
27% EPN (w.p.)	0.75	11	9	5	6
15% parathion (w.p.)	1.0	19	2	3	4
15% parathion (w.p.) + Bordeaux 8-4-100	1.0	37	3	5	5
Untreated		341	275	367	461
Test 5[f]					
8/1		*8/3*	*8/5*	*8/8*	
		(Per terminal)			
Potasan		26	51	30	
Untreated		215	194	212	

[a] Test 2, 3, 4, and 5. Spray mixtures included low soluble copper at 3 to 100 rate and spreader-sticker, 3 oz.
[b] Variety Long Red. Spray mixture contained ziram at 2 to 100 rate and summer oil emulsion, 1 pt.
[c] Variety Rutgers.
[d] Variety Long Red.
[e] Variety Rutgers.
[f] Variety Long Red.

very efficient, being comparable to parathion. Against a severe infestation malathion was about as efficient as the standard material. From the results in table 1 (Test 1) it is seen that malathion at the 1 to 100 rate was definitely inferior to parathion when the infestation was light. In this test the poor performance of the aphicides may in part be attributed to the miscible oil included in the spray mixture. As a supplement for an aphicidal spray mixture on tomatoes miscible oil is considered unsatisfactory. The experimental insecticide NPD gave promising results. In a single trial Potasan was found to be moderately effective against this aphid. Systox at a concentration of 1 ounce of actual toxicant in 100 gallons of water gave excellent control. The performance of the miscible formulations of parathion, malathion and Metacide

Table 2.—Aphicidal efficiency of single applications of organic phosphorous insecticides. 1952.

Formulation[a]	Rate per 100 Gals.	Aphid Population per Terminal After 2 Days	5 Days	7 Days	13 Days	22 Days
Wettable Powders						
15% parathion (w.p.)	1 lb.	2	32	91	161	451
15% parathion (w.p.) Bordeaux 8-4-100	1 lb.	6	60	114	214	445
25% malathion (w.p.)	1 lb.	11	54	87	230	222
25% malathion (w.p.)	2 lbs.	8	19	64	182	201
NPD	1 lb.	11	103	166	398	477
NPD	2 lbs.	7	38	144	330	210
Untreated		295	681	614	756	941
Emulsifiable Liquids						
50% Systox (emul.)	2 oz.	2	16	29	71	85
25% parathion (emul.)	4 oz.	3	44	55	111	185
25% malathion (emul.)	8 oz.	11	65	86	118	116
50% metacide (emul.)	4 oz.	10	62	76	136	302
Untreated		166	272	248	345	582

[a] Applied August 27. Maximum temperature 88° F. Spray mixture included 4 lbs. of low soluble copper (45% copper) and added 2 oz. of *Triton B1956* per 100 gallons of spray containing the wettable powder.

was similar. As far as aphid control is concerned, formulations derived from emulsifiable concentrates showed no advantage over the wettable powders. It is evident from the results from the 1952 experiment that regardless of aphicide tried, a single treatment is inadequate for control when the infestation is severe.

The organic phosphorous insecticides evaluated in this study caused no visible injury. A commercial formulation of TEPP in combination with ziram injured green fruit and "scorched" the foliage. The temperature was 88°F. at time the spray mixture was applied. Injury to fruit by the treatment of TEPP and ziram is shown in Fig. 4.

RESIDUE STUDIES.—The spray residue analyses reported herein were made on green fruit. Analyses made in 1951 were based on fruit taken from plots treated as

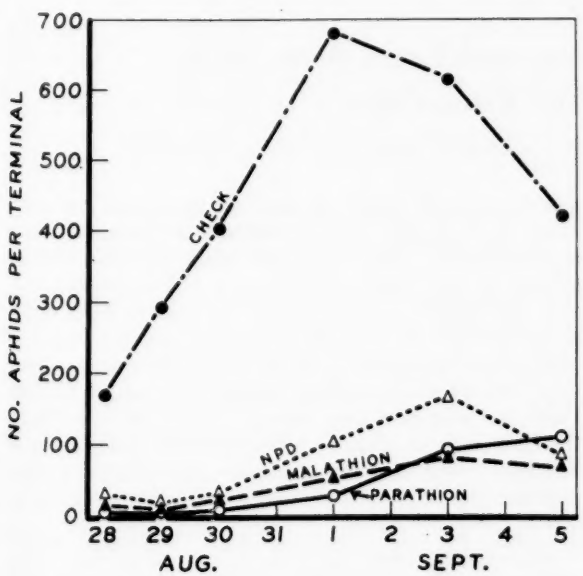

FIG. 3.—Graphic presentation of results with wettable powders of parathion, malathion and NPD.

FIG. 4.—Injury on tomatoes caused by a single treatment of TEPP-ziram spray applied when the fruit was green.

described earlier in this paper. In 1952 samples were taken in plots treated specially for residue analyses. The rate of application was 250 gallons of spray per acre and the pressure was 600 pounds per square inch. All treatments were made with a pendant boom. A low soluble copper fungicide compound was included in the spray mixture along with 2 ounces of a commercial spreader-sticker. Each sample, picked at random from among exposed fruit, contained 12 to 15 tomatoes, varying from 2 to 2½ inches in diameter and weighing approximately 1.5 kgs.

Samples were taken for initial deposits as soon as the spray had dried. In all cases the fruit was stripped within 1 hour after sampling. Malathion residues were stripped with 300 ml. of carbon tetrachloride, while 500 ml. of benzene was used for the removal of parathion residues. Suitable aliquots—varying from 10 to 100 ml.—were taken for analyses. The method employed to determine malathion was developed by Norris *et al.* (1954) and parathion was determined according to the Averell & Norris method (1948).

Results of analyses for 1951 and 1952 are set forth in tables 3 and 4, respectively. It is evident from the data that on tomato fruits both malathion and parathion spray residues are well below 0.1 p.p.m. within a period of 7 to 9 days. Attention is called to the relatively short duration of malathion residue from a treatment with 3 pounds of the insecticide per 100 gallons of spray mixture. Fruit treated with parathion at a concentration twice that

Table 3.—Parathion and EPN spray residues on green tomatoes. 1951.

Formulation[a]	Pounds per 100 Gals.	Number of Samples[b]	Residue p.p.m.[c]
Parathion (15% w.p.)	1.0	3	0.07
Parathion (15% w.p.) Bordeaux 8-4-100	1.0	2	0.02
EPN (27% w.p.)	1.0	2	0.03
EPN (27% w.p.)	0.75	1	0.02

Untreated checks for parathion samples ranged from 0.02 to 0.05 ppm, averaged 0.03 ppm. and for EPN samples ranged from 0.03 to 0.04 ppm, averaged 0.04

[a] Spray mixture contained low soluble copper (52% copper) 3 to 100 rate and DuPont's spreader-sticker, 3 oz.
[b] Samples taken from different experimental blocks.
[c] After 9 days; rainfall 0.27 inches during this period.

Table 4.—Malathion and parathion spray residue on green tomatoes. 1952.

Formulation[a]	Pounds per 100 Gals.	Residue p.p.m. 9/9	9/10	9/11	9/12	9/15	9/16
25% malathion (w.p.)	1.0	0.55	0.17	0.07	0.03	0.01	<0.01
25% malathion (w.p.)	3.0	1.98	1.35	0.29	0.18	0.07	<0.01
15% parathion (w.p.)	2.0	0.62	0.35	0.18	0.12	0.09	0.07

[a] Sprays contained 2 oz. *Triton B1956* and 4 lbs. of low soluble copper (45% copper). Rainfall on 9/16, 1.45 inches. Temperatures ° F: (9/9) 73–46; (9/10) 78–51; (9/11) 89–56; (9/12) 93–58; (9/13) 94–57; (9/14) 94–57; (9/15) 93–56; and (9/16) 70–52.

usually advised for commercial application carried a residue of only 0.07 p.p.m. after 1 week. Within limits the data on parathion residues are in agreement with those reported earlier, Taschenberg (1949). The residues from EPN sprays are of the same magnitude as those from a parathion treatment.

Aside from the foregoing, there were these miscellaneous findings of interest on the 1952 residue studies: Malathion residue values of 2.09 and 1.88 p.p.m. were recorded for duplicate samples picked and stripped within 1 hour after the spray was applied. On green fruit the blanks for malathion were zero. However, a very small blank was found on unsprayed samples of ripe fruit. Prior to stripping an untreated sample of green fruit, malathion was added at rate of 0.64 p.p.m. to the carbon tetrachloride, and by the method of analysis employed 0.63 p.p.m. was recovered.

SUMMARY.—Tomato plantings in western New York may become severely infested with the potato aphid, *Macrosiphum solanifolii* (Ashm.), some seasons. The results from earlier field trials showed parathion to be a very effective aphicide on this crop. Data are presented from comparative studies with seven organic phosphorous materials as aphicides. Systox, at the rate of 1 ounce of actual toxicant per 100 gallons, was the most effective insecticide. Parathion continued to give the usual high degree of control. The addition of bordeaux mixture reduced only slightly the aphicidal performance of parathion. The aphicidal efficiency of malathion and EPN approached that of parathion. Promising results were given by NPD and formulations of emulsifiable concentrates of parathion and malathion and Metacide. The wettable powder formulation of Potasan was inferior to the other materials.

Residues of malathion and parathion were determined on green fruit. The initial analyses were made as soon as the spray had dried and were continued at 24-hour intervals for 1 week. The residues decreased rapidly; within 48 hours after application there was an 87 per cent reduction in the original deposit for malathion and a reduction of approximately 70 per cent for parathion.

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Treatment of Pea, Snap Bean, and Lima Bean Seed with Insecticides and Fungicides[1]

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In Maryland severe early season losses of wrinkled peas and snap and lima beans are occasionally experienced as a result of seed-corn maggot, *Hylemya cilicrura* (Rond.), and seed decay. Such losses have been observed to range in severity from a weakening of plants to completely unsatisfactory stands. This paper is a report of 2 years' work on seed treatment of those crops with the insecticides lindane, aldrin, dieldrin, and chlordane and the fungicides thiram, captan, and chloranil alone and in various combinations. In addition, two commercial preparations (see footnote Table 1) were tested. Each year seed was planted within a few days after treatment and in order to determine the effect of storage, pea seed treated in 1953 was held over and planted in the spring of 1954. Results were based primarily on plant stand counts. Plant stand counts of peas were supplemented by in-soil seed examinations.

PROCEDURE.—All seeds were treated by the slurry method in a laboratory mixer. The slurry was made by dissolving 2 ounces of methyl cellulose per gallon of water and the required insecticide, and fungicide was added to aliquots of this solution. Slurry was used at the rate of 1 pint per bushel of seed in 1953; 0.5 pint in 1954. After treatment, the seed was allowed to dry and was stored in paper bags until planted. The experiments with pea seed were located on the Plant Research Farm at College Park; the snap and lima bean work was carried out on the University of Maryland Vegetable Research Farm at Salisbury. Seed in each experiment was planted in randomized blocks replicated from 5 to 10 times. One hun-

[1] Scientific article No. A501, Contribution No. 2611 of the Maryland Agricultural Experiment Station, Departments of Entomology and Botany. Accepted for publication April 15, 1955.

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Table 1.—Treatments applied to peas, snap and lima beans.

TREATMENT NO.	TOXICANT	AMOUNT ACTUAL PER BUSHEL OF SEED (OZ.)
1	Lindane	25% W.P.—0.25
2	Lindane	25% Emul.—0.25
3	Lindane+chloranil	25% Emul.—0.25+chloranil—1
4	Chloranil	1
5	Lindane+thiram[a]	1.75
6	Lindane+captan[b]	1.5
7	Check	
8	Chlordane+chloranil	46% Emul.—1+chloranil—1
9	Chlordane+chloranil	50% W.P.—1+chloranil—1
10	Aldrin+chloranil	23% Emul.—0.25+chloranil—1
11	Dieldrin+chloranil	18.5% Emul.—0.25+chloranil—1
12	Thiram	75%—1.5
13	Captan	75%—1.5
14	Dieldrin	18.5% Emul.—0.25
15	Lindane	25% Emul.—1
16	Aldrin	23.1 Emul.—0.5
17	Chlordane	46% Emul.—0.5
18	Chloranil	2
19	Lindane+chloranil	25% Emul.—0.25+chloranil—2
20	Dieldrin+thiram	18.5% Emul.—0.25+thiram—1
21	Chlordane+thiram	46% Emul.—0.5+thiram—1
22	Chlordane	46% Emul.—0.5

[a] Seed Guard, manufactured by the California Spray Chemical Co.
[b] I and D Seed Protectant, manufactured by the E. I. DuPont de Nemours Co.

dred seeds were planted in each plot where plant stand counts were made. Peas were planted 1 inch apart by means of a small "counter-spacer" made for the purpose. Snap and lima beans were planted by hand 2 inches or 4 inches apart. The various treatments applied in 1953 and 1954 are given in table 1.

PEA SEED, 1953 TREATMENTS AND RESULTS.—Seed of the Thomas Laxton variety of canning peas was treated on April 1 and planted on April 17. Treatments were replicated 6 times and 125 seeds were planted in each plot, 100 for stand counts and 25 for in-soil examination. Stand counts were made on May 27 when the number of both strong and weak plants was recorded. In-soil examination of two 25 seed replicate rows of each treatment was made on May 4. The results of stand counts are given in table 2.

The weather immediately following the planting of peas in 1953 at College Park was cool and wet, the kind of weather in which heavy loss may be expected from decay organisms. The plant stands of various treatments varied greatly and the results of the pea seed experiments may be summarized as follows: (1) With the exception of lindane wettable powder, all treatments resulted in significantly better stands than the untreated seed. (2) The stand of plants in the lindane wettable powder treatment was significantly poorer than in the lindane emulsion treatment. (3) Commercial combinations of thiram with lindane, and captan with lindane gave significantly better results than laboratory-prepared combinations of chloranil with lindane, chlordane, aldrin, and dieldrin. Differences may be accounted for in part by differences in dosage. (4) Treatment with thiram alone and with captan alone resulted in significantly better stands than treatment with the chloranil alone. (5) While the insecticides used did not entirely prevent maggot infestation of seed, they reduced it. All non-germinated seed that received no treatment, or fungicides only, was infested on May 4.[3] (6) In-soil examination of seed on May 4 showed that where thiram and captan were used there was a higher number of sound cotyledons attached to growing plants than where other materials had been used.[3] (7) In treatments where thiram and captan were used alone decay of the cotyledons on growing plants was prevented and maggot infestation of sound seed was very low (Fig. 1). In these treatments only the decaying non-germinating seed was totally infested.[3] These observations indicate that the seed-corn maggot is primarily a scavenger, preferring decaying organic matter as food. For this reason more extensive in-soil observations were made in 1954.

Table 2.—Average pea stands for the 1953 treated seed planted on April 17, 1953 and on April 9, 1954.

TREATMENT AND NO.	1953 Average No. Plants per Plot		1954 Average No. plants per Plot	
	Strong Plants	All Plants	Strong Plants	All Plants
1. Lindane W.P.	14.7	16.1	45.5	47.8
2. Lindane Emul.	23.2	25.5	47.1	49.4
3. Lindane-chloranil	29.8	33.6	49.1	50.4
4. Chloranil	20.2	22.6	53.0	55.5
5. Lindane-thiram	42.3	46.3	54.0	57.1
6. Lindane-captan	53.2	57.5	55.1	57.7
8. Chlordane-chloranil	38.2	42.0	49.0	50.1
9. Chlordane W.P.-chloranil	28.2	29.3	48.8	50.9
10. Aldrin-chloranil	31.8	33.5	51.6	53.7
11. Dieldrin-chloranil	33.8	35.6	48.5	49.6
12. Thiram	44.3	48.3	49.5	52.5
13. Captan	49.7	52.5	51.0	54.1
7. Check	11.0	12.0	43.3	47.8
L.S.D. at 5% level	8.3	8.1	NS	NS

Table 3.—Average plant stands of 1954 pea seed planted in 1954.

TREATMENT NO.	TREATMENT	AVERAGE NO. OF PLANTS PER PLOT	
		Strong Plants	All Plants
14	Dieldrin	22.5	23.5
2	Lindane 0.25 oz.	21.8	23.4
15	Lindane 1 oz.	17.1	18.7
16	Aldrin	19.1	20.2
17	Chlordane	22.6	24.4
12	Thiram	20.8	27.1
13	Captan	20.5	24.3
18	Chloranil	18.8	22.6
5	Lindane+thiram	27.3	29.8
6	Lindane+captan	21.0	25.0
19	Lindane+chloranil	28.1	30.6
7	Check	18.8	22.8
	L.S.D. @ 5% level	NS	NS

PEA SEED, 1954 TREATMENTS AND RESULTS.—The 1954 experiments were divided into three parts. An unplanted portion of 1953-treated seed which had been held over in the laboratory was planted on April 9. The same treatment numbers were given and replications were made as in the preceding year (Tables 1 and 2). The results are based on stand counts made on May 5.

The second planting consisted of 1954 seed on which 11 different treatments (Tables 1 and 3) were applied. The seed was of the Pride variety which was of low vitality, germinating only 56.6 per cent in the laboratory. Treatments were applied March 22 and the seed was handled in the same way as during the previous year. Six replications of all treatments were planted on April 9; results are based on stand counts made on May 5 (Table 3).

[3] Supporting data in possession of the authors.

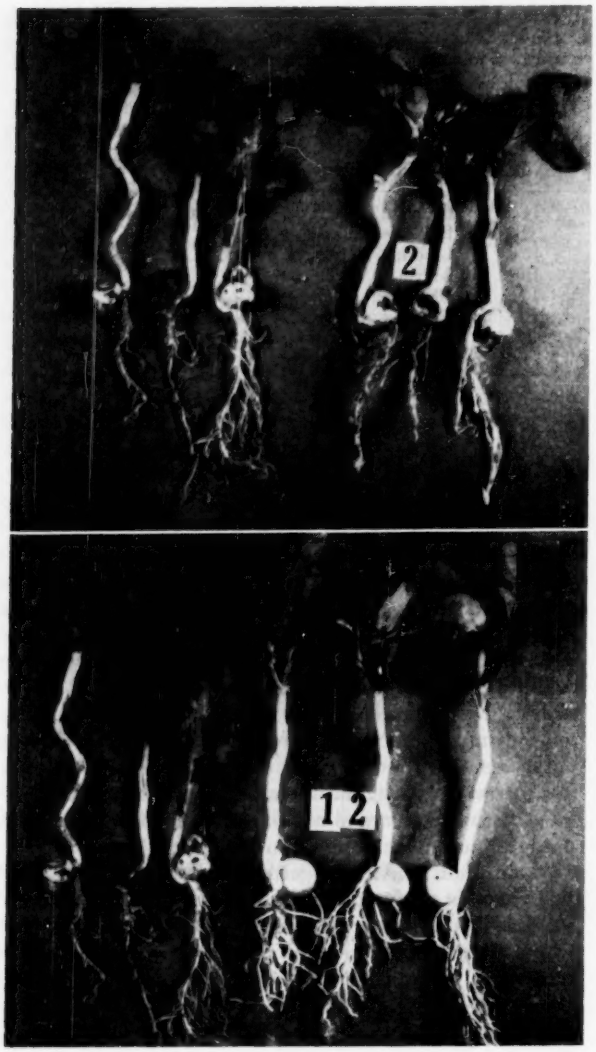

FIG. 1.—Pea seed removed from the soil 17 days after planting (1953) showing seed decay of untreated seed (left, top and bottom) and lindane-treated seed (treatment 2 above). Sound seed protected by thiram (treatment 12) produced more vigorous plants.

The third planting, for in-soil examinations, consisted of 4 replications of untreated seed and of 1954 seed treated with lindane alone, captan alone, and lindane plus thiram (treatments 2, 13, 5, & 7, Table 1). It was planted on April 9. Twenty-five seed from each replication of each treatment were dug and examined for decay and maggot infestation on five different dates (Table 4).

The apparent results of the 1954 pea seed experiments may be summarized as follows: (1) Observations indicate that there was no significant reduction of plant stand that could be attributed to injury by insecticides and fungicides when seed was held for 1 year after treatment. (2) It appeared from in-soil examination that seed treated with lindane alone was more susceptible to infection and subsequent growth of fungus (probably *Pythium* sp.) as is indicated by the higher number of decayed uninfested seed in treatment 2 of table 4. Lindane-treated ungerminated seed quickly became covered with mycelium of the fungus (Fig. 2). (3) Lindane delayed maggot infestation of seed but did not prevent attack; eventually a high proportion of such seed became infested (Table 4, treatments 2 and 7). Seed-corn maggots in 1954 were observed to attack both germinating and decaying ungerminated seed, though the latter were preferred.

LIMA BEANS, 1953 AND 1954.—In 1953 "Fordhook 242" lima bean seed was given the same treatments as peas had received. Treatments were applied on April 2, 1953, and seed was planted on April 29 at Salisbury in 100-seed plots replicated 5 times. The soil in this region is a well-drained, light, sandy type in contrast to the heavier loam soils in plots at College Park. The results of treatments are based on plant stand counts made on May 22 and are given in table 5.

In 1954 twelve treatments were applied to "Fordhook 242" on March 23 and the seed was planted on May 1 at Salisbury in 100-seed plots replicated 6 times. The results are based on stand counts made June 3 (Table 5).

In 1953 Fordhook seed from the spring-treated lots was planted in August of the same year; in 1954 Henderson lima seed, which received the same treatments as the 1954 Fordhook seed, was planted in August. Plant stands of over 90 per cent were secured in these late season plantings for all treatments and for untreated seed and there was no evidence of injury to the seed by any of the treatments.

In the spring of 1953 Fordhook lima beans responded in a similar manner to wrinkled peas. The highest plant stands were secured with thiram and captan alone and with these two fungicides in combinations with lindane. Treatments with the insecticides alone, and with chloranil and chloranil-insecticide combinations (treatments 1, 2, 3, 4, 8, 9, 10, 11, Table 5) resulted in significantly poorer stands than where thiram and captan were applied (treatments 5, 6, 12, 13, Table 5). None of the treatments applied in the 1953 spring experiment produced commercially satisfactory stands of Fordhook limas.

In 1954 more satisfactory stands were secured. In these experiments neither chloranil, thiram, nor captan alone increased the stand significantly over untreated seeds but all the insecticide treatments, alone or in combination with a fungicide, resulted in higher stands than untreated seed or seed with fungicide alone. Highest stands were secured in treatments 2, 5, and 19 (Table 5) where lindane was used, though the differences are not significant over other insecticides.

SNAP BEAN EXPERIMENTS.—In the spring of 1953 Top Crop snap bean seed was given the same treatments as wrinkled peas. They were applied on April 2 and the seed was planted at Salisbury on April 18 in 100-seed plots, replicated 6 times. Results based on stand counts made on May 22 are given in table 5. In 1954 Black Valentine snap bean seed was given the same treatments at the same time as 1954 Fordhook lima bean seed and was planted on May 1 as Salisbury. All treatments were replicated 10 times in 100-seed plots. Stand counts made on June 3 are given in table 5.

Highest plant stands in 1953 were secured with insecticide-fungicide combination treatments. There was no significant difference between any of the combinations tried, though the lindane-chloranil treatment (treatment 3, Table 5) was lower than the others, the difference ap-

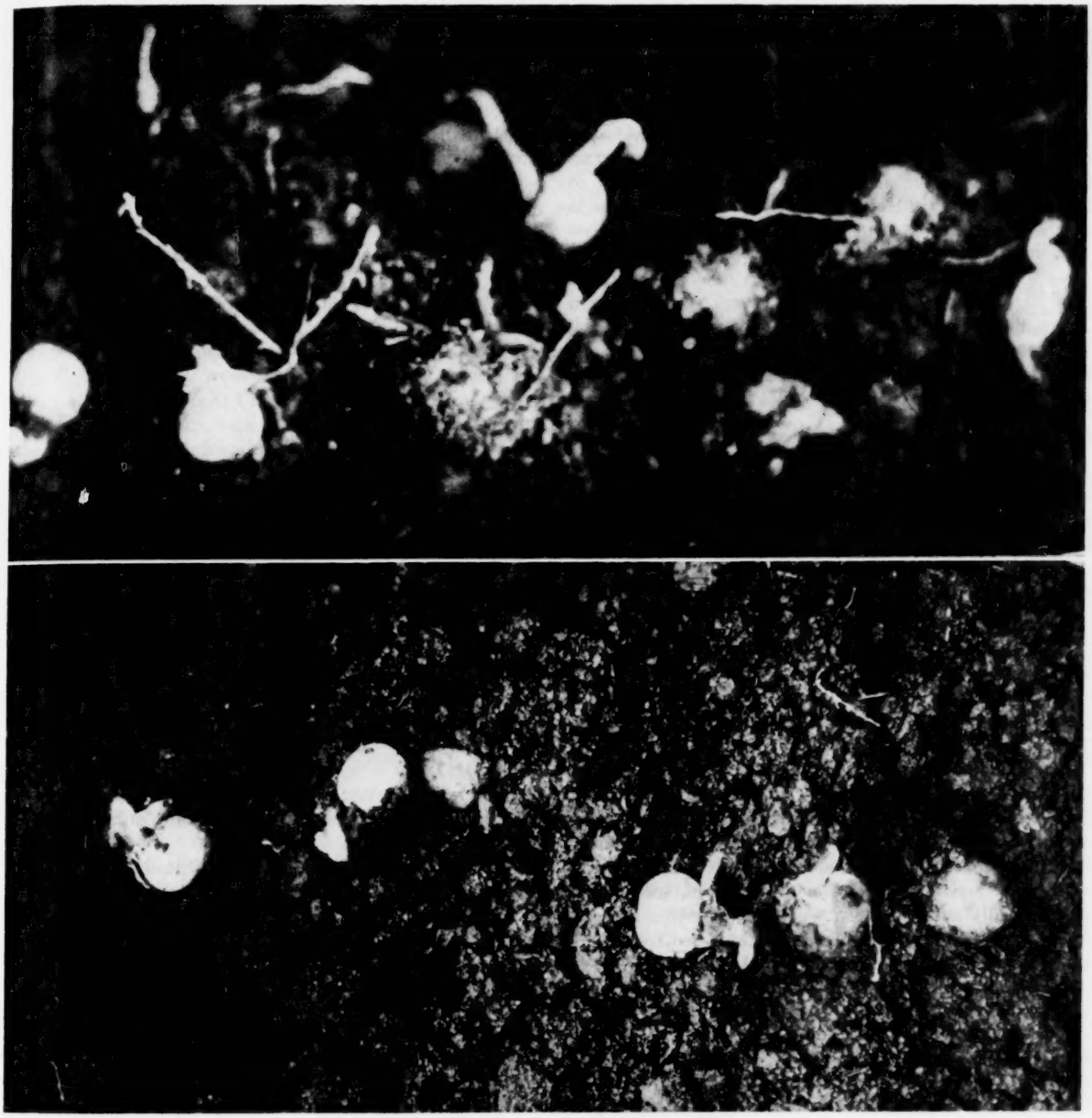

FIG. 2.—In-soil picture of 1954 pea seed 5 days after planting. Below, treatment number 5, lindane plus thiram; above, treatment 2, lindane only. Note vigorous fungus growth on the pericarp of several lindane-treated seed.

proaching significance at the 5 per cent level. The stands were at a satisfactory commercial level. In 1953 significantly poorer results were secured with lindane W. P. alone (treatments 1 and 2) and with fungicides alone (treatments 4, 12, and 13). For chloranil the stand was lower, but not significantly lower than for the untreated check.

In 1954 stands for all treatments in which insecticides were used either alone or in combination were significantly higher than stands for treatments where fungicides were used alone or for the check plots.

As with lima beans, the 1953 and 1954 snap bean experiments were repeated in August of both years. Stands of all treatments were well above 90 per cent and there were no differences between any treatments or the untreated checks.

DISCUSSION.—Results of seed treatments for control of seed-corn maggot and seed decay were exceedingly variable and to a considerable extent in agreement with the findings of Lange *et al.* (1951). The most important factors influencing this variability appear to be temperature and soil moisture, variety of seed, seed vitality, and the fauna and flora of the soil. The results of experiments reported here indicate that cold and wet soil favors the development of decay organisms and that the highest plant stands are secured under those conditions by the use

Table 4.—Results of in-soil examinations of treated pea seed planted April 9, 1954.

Treatment No. and Date Examined	Total Number of Peas for Each Treatment							
	Recovered	Germinated	Dry	Swelled	Decayed and Infested	Sound and Infested	Total Infested	Decayed not Infested
April 13								
7 check	92	22	24	46	0	0	0	0
2 lindane	80	24	9	46	0	0	0	1
13 captan	100	10	31	59	0	0	0	0
5 lindane+thiram	101	21	17	63	0	0	0	0
April 15								
7 check	96	34	8	25	5	5	10	19
2 lindane	98	21	31	6	0	5	5	35
13 captan	100	30	7	35	2	3	5	23
5 lindane+thiram	101	33	20	36	0	4	4	8
April 18								
7 check	91	32	0	15	28	2	30	14
2 lindane	82	25	0	29	3	0	3	18
13 captan	98	43	0	22	17	13	30	3
5 lindane+thiram	90	40	0	18	15	1	16	16
April 20								
7 check	80	34	0	1	42	0	42	3
2 lindane	76	25	0	2	8	0	8	34
13 captan	75	38	0	3	26	0	26	8
5 lindane+thiram	88	46	0	0	27	0	27	15
April 26								
7 check	46	9	0	0	16	21	37	0
2 lindane	78	28	0	0	34	8	42	8
13 captan	55	10	0	0	22	23	45	0
5 lindane+thiram	63	23	0	0	28	6	34	6

of fungicides. When soils are cool and on the dry side (moist but not wet) greatest reduction in plant stand results from maggot injury; under those conditions greatest benefit is secured by use of an insecticide. When soils are warm and moisture content near optimum, seed germinates rapidly and is not seriously affected either by seed-corn maggot or decay organisms so that seed treatments are not necessary; on the other hand conditions may be so adverse that even with combination fungicide-insecticide treatment a satisfactory stand of plants cannot be produced.

The 1953 in-soil examinations indicated that seed-corn maggots were primarily scavengers feeding on decaying plant material in the soil because seed that had been protected from rots was not observed to be infested with maggots. More extensive in-soil examinations of pea seed

Table 5.—Plant stands of lima and snap beans for 1953 and 1954.

1953			1954		
	Average Number of Plants per Plot			Average Number of Plants per Plot	
Treatment and Number	Lima	Snap	Treatment and Number	Lima	Snap
1 Lindane W. P.	10.8	67.3	2 Lindane	86.9	91.4
2 Lindane	18.0	72.5	5 Lindane+thiram	89.7	91.6
3 Lindane+chloranil	11.8	77.2	6 Lindane+captan	88.3	91.1
4 Chloranil	16.4	61.8	12 Thiram	73.7	83.1
5 Lindane+thiram	29.0	79.2	13 Captan	79.0	83.7
6 Lindane+captan	32.8	78.2	14 Dieldrin	82.7	94.3
8 Chlordane+chloranil	17.6	79.2	18 Chloranil	76.2	84.8
9 Chlordane W. P.+ chloranil	8.0	79.2	19 Lindane+chloranil	88.0	93.5
10 Aldrin+chloranil	8.8	77.7	20 Dieldrin+thiram	81.0	93.7
11 Dieldrin+chloranil	13.0	77.3	21 Chlordane+thiram	83.0	93.6
12 Thiram	26.0	65.8	22 Chlordane	87.0	93.8
13 Captan	25.8	67.3			
7 Check	10.0	65.5	7 Check	73.8	85.3
L.S.D. at 5% level	8.8	8.0		8.1	4.7

in 1954, indicated, however, that this was not true. Though decaying seed is attacked quickly by maggots, eventually sound seed and the stems of growing plants may also be severely injured (see check treatment 7, Table 4). Pea cotyledons remain in the soil attached to the young plant, where in cool weather maggot injury is followed by decay organisms. The late maggot attack on the cotyledons of germinated peas seemed to stunt the growing plants often to the extent that they never recovered normal vigor. In warm weather maggot-injured bean cotyledons may grow out of the soil before they decay.

Direct injury to seed by lindane or any of the other insecticides when used without a fungicide is not clearly indicated in these experiments. Though poor stands sometimes resulted, they were never significantly lower than those of untreated peas (Tables 2, 3 and 5). Though response to treatments with lindane alone, particularly in the wettable powder forms, was exceedingly poor in some early spring experiments, there was no reduction of stand in summer-planted seed. In-soil examination of treated pea seed indicated that lindane stimulated the growth of fungi (probably *Pythium* sp.) over the seed but the cause was not ascertained. That the pericarp may have been injured by lindane and thus made more susceptible to the fungus is only speculative. The pea seed on which these observations were made was of low vitality, which also may have been a factor.

SUMMARY.—Results of seed treatments were extremely variable, depending on weather and a number of other factors. When soil conditions were extremely unfavorable to seed germination or when warm, moist soil was favorable to rapid germination little benefit was obtained from seed treatments. Between these extremes excellent response was obtained from seed treatments. In Maryland, treatments should consist of both fungicide and insecticide. In these experiments the fungicides captan and thiram performed more satisfactorily than chloranil. There were no significant differences observed in the performance of lindane, chlordane, aldrin, or dieldrin when used as emulsions. All treatments were by the slurry method.

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Factors Affecting Pinhole Injury to Dry Peas by the Pea Weevil[1]

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The pea weevil, *Bruchus pisorum* (L.), causes two types of injury to dry peas. One type results when the larva completes its development, and a less obvious type, called pinhole injury, when it dies before it has done much feeding. Peas in which the larvae have reached maturity have large cavities and weigh less than sound peas, and so can be removed by gravity separation machines or by flotation in brine. Since peas in which the larvae have fed only slightly are nearly as heavy as sound peas, these methods do not remove them.

From 1940 to 1946 studies were made in the Palouse area of Idaho to determine whether certain environmental factors or methods of growing the peas affected the amount of pinhole injury. Samples of peas from the experiments were examined for both types of injury. Peas injured by the mature larvae were removed by flotation in brine and the pinhole-injured peas were picked out from the remainder. The percentage of weevil-injured peas with pinhole injury was then calculated.

EFFECT OF SHADE.—It was thought that pinhole injury might be affected by shade. In 1940, 1941, and 1942 experiments were conducted in which some plots were shaded with canvas stretched over frames in such a way that air could circulate freely over the vines. Twelve pairs of plots were used in 1940, seven in 1941, and three in 1942. One thousand peas from each plot were examined for weevil injury in 1940 and 2000 in 1941 and 1942. The results are summarized in table 1. In 1940 and 1941 pinhole injury was lower in the shaded peas, but in 1942 there was practically no difference.

A study was made of the maximum daily temperatures, as recorded by the United States Weather Bureau at Moscow, Idaho, during the approximate period when newly hatched larvae would be entering the peas (Table 2). This period was considered to begin 15 days after the first eggs were laid.

The distribution of warm periods in the different years indicates that high temperature may affect early larval development. In 1940 and 1941 temperatures over 80° F. occurred early, but in 1942 not until the ninth day. Shade did not reduce pinhole injury in 1942 but reduced it about 57 per cent in 1940 and 1941. This indicates that high temperatures during the early part of the period killed some of the small larvae after they had entered the peas.

EFFECTS OF TIME OF PLANTING AND CUTTING.—Since the percentage of pinhole injury was often greater in peas that were planted late in the season, it was thought that depleted soil moisture and weather conditions that cause rapid maturing of the vines might be partly responsible. It was also suspected that the practice of cutting the vines before they were ripe might increase pinhole injury.

Experiments on the effect of early and late plantings

[1] Accepted for publication April 15, 1955. In cooperation with the Idaho and Washington Agricultural Experiment Stations.

Table 1.—Effect of shading the vines on pinhole injury to peas. Moscow, Idaho.

Year	Per Cent of Clear Days	Weevil—Injured Peas: Total Number		Weevil—Injured Peas: Per Cent with Pinhole Injury	
		Shaded	Unshaded	Shaded	Unshaded
1940	75	1369	5277	1.5	3.5
1941	38	1936	8876	1.3	3.0
1942	68	522	560	1.5	1.2

of peas were begun in 1941 and continued through 1946. The differences were within the limits of experimental error except in 1945, when the percentage of pinhole injury was greater in the late crop, and in 1946, when the reverse was true. In 1945 the early peas ripened slowly and the late peas prematurely, and in 1946 the reverse was true. These results indicate that rapid ripening or conditions associated with it cause an increase in pinhole injury and that time of planting has no direct effect. In the Palouse area the late peas are more likely to ripen prematurely than early peas.

Beginning in 1943 the effect of the time of cutting the pea vines was also studied in these experiments. The vines were cut four times each year. The first cutting was made while the vines were still green and before the lower pods had completely hardened, the second and third cuttings 4 or 5 days after the previous ones, and the last cutting after the vines were dead and the peas hardened. Table 3 shows that the time of cutting had a marked effect on the amount of pinhole injury. Each year there was a decrease as the cutting was delayed. This decrease was statistically significant in 1945 and 1946 except for the difference between the second and third cuttings in 1946. Similar results were obtained in groups of six replicates of the experiment at Moscow and Lewiston in 1945 and at Moscow, Genesee, and Lewiston in 1946 (Fig. 1).

Table 2.—Maximum daily temperatures at Moscow Idaho, during the period weevil larvae were entering the peas.

1940		1941		1942	
Date	Temperature, ° F.	Date	Temperature, ° F.	Date	Temperature, ° F.
June 30	76	June 8	57[a]	June 21	68
July 1	87	9	66[a]	22	75
2	84	10	74	23	71[a]
3	89	11	84	24	60[a]
4	85	12	89	25	50[a]
5	80	13	71[a]	26	59[a]
6	82	14	80[a]	27	64[a]
7	85	15	67[a]	28	75
8	88	16	68[a]	29	85
9	85	17	68[a]	30	91
10	88	18	63[a]	July 1	93
11	99	19	63[a]	2	92
12	90	20	69[a]	3	94
13	80	21	83[a]	4	86[a]
14	88	22	84	5	84

[a] Cloudy day; all other days were clear.

Table 3.—Per cent of weevil-injured peas with pinhole injury as affected by time of planting and cutting. Moscow, Idaho.

Year and Planting Time	First Cutting	Second Cutting	Third Cutting	Fourth Cutting
1943				
Early	2.1	1.3	1.1	0.8
Late	2.6	3.0	1.1	1.2
1944				
Early	5.6	3.7	8.7	3.4
Late	13.6	8.4	4.1	5.3
1945				
Early	17.1	16.5	9.6	4.2
Late	34.5	26.8	19.8	6.5
1946				
Early	17.8	14.4	14.6	3.6
Late	18.3	7.1	5.6	2.7
Average				
Early	10.7	9.0	8.5	3.0
Late	17.3	11.3	7.7	3.9

Effect of Location.—In 1945 and 1946 pinhole injury was significantly greater at Lewiston than at Moscow (Table 4). It was also greater at Genesee than at Moscow in 1946, but the difference was not statistically

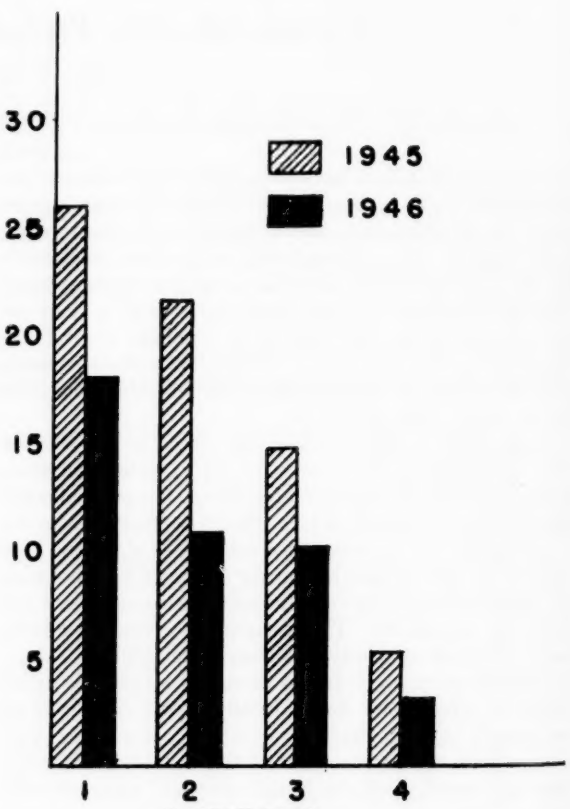

Fig. 1.—Per cent of weevil-injured peas with pinhole injury in consecutive cuttings.

Table 4.—Effect of location on per cent of weevil-injured peas with pinhole injury.

YEAR AND PLANTING TIME	ALL CUTTINGS			LAST CUTTING		
	Moscow	Lewiston	Genesee	Moscow	Lewiston	Genesee
1945						
Early	7.5	16.2	—	2.5	5.9	—
Late	16.6	27.2	—	2.7	10.4	—
1946						
Early	12.6	15.4	9.8	2.1	5.4	3.4
Late	6.6	11.4	7.3	0.7	6.5	1.1

significant. Moscow and Genesee are at about the same elevation of 2500 feet and have similar precipitation and temperatures, but Lewiston, although less than 35 miles south of Moscow, is nearly 2000 feet lower. Temperatures were about 6° F. higher at Lewiston in both years, and there was 10.65 inches more precipitation at Moscow in 1945 and 8.21 inches more in 1946. It appears that the greater pinhole injury at Lewiston was caused by rapid ripening of the peas due to the warmer, drier climate.

DISCUSSION.—The control of adult pea weevils decreases pinhole injury by preventing egg laying. Control is more difficult on early crops, which frequently have large numbers of weevils moving into them. Unless a good job is done, the advantage gained by early planting may be overcome by increased infestation. After the eggs are deposited on the pods there is no practical method of preventing the larvae from entering the peas. After the larvae have entered the peas, they should be allowed to develop until they have consumed enough to make separation from sound peas practical.

These experiments indicate that the larvae are killed by rapid hardening of the peas, resulting from either hot, dry weather or early cutting. Therefore a grower has two means of reducing pinhole injury in addition to adult weevil control. First, he can plant early with the expectation that in most years the crop will mature before the weather becomes hot and dry. Second, he can delay harvest until the peas are ripe. Both these measures are in accord with good cultural practices. Larger yields are usually obtained with early crops. Early cutting of the vines is believed to be a cause of poor germination in seed peas and also of poor quality in dry edible peas because of shriveling.

Summer Control of the Apple Aphid[1]

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The apple aphid, *Aphis pomi*, DeG., is a common pest in western New York apple orchards, being most troublesome in vigorously growing trees. Control measures available heretofore have not proved very satisfactory. Dormant applications of dinitro materials (Elgetol,[2] dinitrobutylphenol, Elgetol 318,[3] etc.) will kill the overwintering eggs of this aphid but the treatment generally is not sufficiently efficient to provide full season protection. Usually, the effect is merely to delay the time of summer buildup. A number of insecticides have been used to cope with summer infestations of the aphid including nicotine sulfate, TEPP, parathion and others. While many of these materials will kill aphids wet with the spray enough individuals often survive treatment to produce heavy reinfestations. Factors that account for such results are: incomplete spray coverage, short residual activity of the insecticide and insufficient toxicity of the material or spray mixture used. This problem has been discussed by Cutright (1953).

This paper reports the results of 3 years' field tests against the apple aphid. It includes an evaluation of old and new insecticides for their aphicidal value against this species and also compares the efficiency of various methods of applying the sprays.

METHODS.—All tests reported here were conducted in a block of Red Delicious and Rhode Island Greening apple trees. The planting was 5 years old in 1952 when the first work was done. The trees were in excellent vigor and aphids were abundant each of the 3 years during which tests were conducted here from late June through mid-August on all terminal growth and on the water sprouts. Single tree plots were used with replications and block arrangements variable from year to year. Each test tree was thoroughly sprayed using a spray gun at 550 pounds pressure.

Results were measured 48 hours after treatment by clipping 4 inches from the tip of 10 terminals from each test tree. At this time one could readily determine whether or not any given terminal had been infested at the time of spraying. Only previously infested terminals were selected in sampling. Terminals were dropped into paper bags and brought to the laboratory where they were placed in Berlese funnels. Aphids were trapped in 70 per cent alcohol and were counted later when time permitted.

Additional records were taken at approximately weekly intervals by making an estimate of the population level in each tree. Two observers rated the trees on the basis of per cent of the check populations. In 1952 the ratings were made as 0, 25, 50, 75 and 100 per cent while in the other years it was on the basis of 10 per cent gradients.

Other experiments have been conducted using hydraulic high pressure sprayers and several types of airblast equipment under commercial orchard conditions on mature trees. These results will be reported in a later paper.

[1] Journal Paper No. 1002, New York State Agricultural Experiment Station, Geneva, N. Y., April 11, 1955. Accepted for publication April 15, 1955.

[2] Contains dinitrocresol.

[3] Contains dinitrobutylphenol.

Table 1.—Summer control of the apple aphid, Sodus, N. Y. 1952.

Material	Rate per 100 Gal.	Per Cent Reduction	
		48 Hours	2 Weeks
July 7 series			
20% TEPP	2 fl. oz.	59	0
20% TEPP	4 fl. oz.	68	0
20% TEPP	8 fl. oz.	89	0
15% parathion	0.5 lb.	63	0
15% parathion	1 lb.	81	0
15% parathion	2 lbs.	83	0
15% parathion+spreader	0.5 lb.+6 fl. oz.	66	0
25% parathion emulsifiable	2 fl. oz.	22	0
33% methyl parathion	2 fl. oz.	63	0
25% malathion	2 lbs.	96	50
50% malathion emulsifiable	16 fl. oz.	95	25
30% Chlorthion	0.5 lb.	89	0
85% NPD emulsifiable	8 fl. oz.	55	0
42% demeton	1 fl. oz.	90	50
42% demeton	2 fl. oz.	96	50
42% demeton	4 fl. oz.	96	75
25% Isolan	4 fl. oz.	95	50
25% Isolan	8 fl. oz.	97	75
25% lindane	1 lb.	98	25
40% nicotine sulfate+lime	12 fl. oz.+1 lb.	85	0
Check	—	(848 aphids per terminal)	
July 22 series			
25% malathion	0.5 lb.	98	25
25% malathion	1 lb.	94	0
25% malathion	2 lbs.	99	0
33% methyl parathion	8 fl. oz.	93	25
42% demeton	8 fl. oz.	99	75
42% demeton	16 fl. oz.	99	100
25% Isolan	2 fl. oz.	97	25
25% Isolan	16 fl. oz.	99	75
Check	—	(465 aphids per terminal)	

MATERIALS.—Standard brands of insecticides were used where available. In addition to those included in the list of common names by Haller (1955) the following were included in experiments reported here:

4389. S-(1,2 - dicarbethoxy ethyl) 0,0 - dimethyl thiophosphate. American Cyanamid Co.

OS 2046. 2 - carbethoxy-1-methylvinyl dimethyl phosphate. Shell Development Company.

OS 1808. 2 - carbethoxy-1-methylvinyl diethyl phosphate. Shell Development Company.

22870. 5 - (3 - methylpyrazolyl) N, N dimethyl carbamate. Geigy Co., Inc.

Meta-Systox. 0,0 - dimethyl 0-2-ethylmercaptoethyl thiophosphate

RESULTS.—The 1952 tests were replicated three times on the Red Delicious variety. Two test series were included; the first was applied on July 7 and the second on July 22. On July 7 the temperature was 88° at midafternoon and the day was clear with a 5 to 10 mile an hour breeze. On July 22 the temperature reached 90° and again it was clear and somewhat windy.

The results of the two series are given in table 1. It is readily apparent that commercially used aphicides were not very effective at 48 hours and particularly 2 weeks after treatment under the conditions of this test. Thus parathion, TEPP and nicotine sulfate killed less than 90 per cent of the aphids at 48 hours and aphid populations had returned to check levels 2 weeks after spraying. Malathion and lindane at the dosages used were effective at 48 hours but had little or no residual activity. Demeton and Isolan were very effective at 48 hours and kept the populations at a low level for a period of about 2 weeks. After that time aphids became established and multiplied readily on the newest growth.

The 1953 tests were again run in two series with treatments made on July 13 and 28 as indicated in table 2. Both days were sunny and warm with maximum temperatures of 82° and 85°, respectively. The winds were variable at 3 to 5 miles per hour. Each treatment was applied to one Delicious and one Greening tree. In addition to the 48-hour and 2-week data, records were also obtained at 3 and 4 weeks for some of the plots.

TEPP, parathion and nicotine sulfate gave better kills than in 1952 but there was no evidence of residual effectiveness in the first test. The apparent residual activity in the July 28 series was probably due to the fact that the aphid population was generally on the decline. Several other chemicals performed similarly to parathion including malathion, Chlorthion, 4389, lindane, and endrin. The systemic insecticides, demeton, Meta-Systox and Isolan, gave excellent control of aphids for 1 to 2 weeks at the lower dosages and for 3 or more weeks at the higher levels.

The 1954 test series was applied on July 6 with each treatment replicated three times on single Red Delicious trees. The day was clear with a maximum temperature of 75°. The wind was at 5 to 10 miles per hour.

The results are given in table 3. TEPP and parathion performed rather poorly as they did in 1952. Malathion, Chlorthion, Diazinon, OS-2046 and lindane gave good initial kill but very little residual effectiveness. Again the systemic materials gave the best results. Demeton and Meta-Systox had more residual activity than American Cyanamid 12008 and 12009 or OS-1808 and OS-2046. The G-22870 was quite effective at the dosage used.

DISCUSSION.—The data given in the tables show that there are many chemicals that are toxic to the apple aphid

Table 2.—Summer control of the apple aphid, Sodus, N. Y. 1953.

Material	Rate per 100 Gal.	Per Cent Reduction			
		48 Hrs.	2 Wks.	3 Wks.	4 Wks.
July 13 series					
40% TEPP	4 fl. oz.	91	25	0	—
40% TEPP	8 fl. oz.	90	25	0	—
15% parathion	0.5 lb.	88	25	0	—
15% parathion	1 lb.	98	25	0	—
15% parathion	2 lbs.	96	50	0	—
25% malathion	0.25 lb.	84	25	10	—
25% malathion	0.5 lb.	90	25	10	—
25% malathion	1 lb.	96	50	10	—
25% malathion	2 lbs.	96	50	10	—
25% Chlorthion	0.5 lb.	92	50	10	—
25% Holcomb Compd. 326	16 fl. oz.	93	25	10	20
25% 4389	0.5 lb.	92	25	20	0
25% 4389	1 lb.	86	50	20	0
21% demeton	1 fl. oz.	82	50	20	20
21% demeton	4 fl. oz.	93	75	50	20
21% demeton	16 fl. oz.	97	75	80	30
50% Meta-Systox	4 fl. oz.	94	50	40	0
50% Meta-Systox	16 fl. oz.	92	75	60	10
25% Isolan	1 fl. oz.	95	75	50	10
25% Isolan	4 fl. oz.	84	75	60	30
25% Isolan	16 fl. oz.	94	75	80	50
40% nicotine sulfate	12 fl. oz.	90	50	10	—
25% lindane	1 lb.	96	50	10	—
18% endrin	16 fl. oz.	98	25	10	—
Check	—	(320 aphids per terminal)			
July 28 series					
40% TEPP	4 fl. oz.	88	50		
25% malathion	1 lb.	95	50		
15% parathion	1 lb.	96	60		
25% Chlorthion	0.25 lb.	90	10		
25% Chlorthion	0.5 lb.	99	50		
25% Chlorthion	1 lb.	99	80		
25% 4389	0.25 lb.	47	0		
25% 4389	0.5 lb.	97	50		
25% 4389	1 lb.	99	60		
Check	—	(1040 aphids per terminal)			

Table 3.—Summer control of the apple aphid, Sodus, N. Y. 1954.

Material	Rate per 100 Gal.	Per Cent Reduction	
		48 Hours	2 Weeks
20% TEPP	8 fl. oz.	70	14
15% parathion	1 lb.	74	31
25% malathion	1 lb.	93	30
25% Chlorthion	0.5 lb.	95	34
25% Holcomb Cmpd. 326	1 lb.	51	0
25% Diazinon	1 lb.	92	44
OS 2046	1.25 fl. oz.	98	54
25% OS 1808	5 fl. oz.	78	50
21.2% demeton	4 fl. oz.	98	80
21.2% demeton	8 fl. oz.	92	87
47% Meta-Systox	4 fl. oz.	98	80
47% Meta-Systox	8 fl. oz.	99	87
50% American Cyanamid 12008	4 fl. oz.	88	27
50% American Cyanamid 12008	8 fl. oz.	98	64
50% American Cyanamid 12009	4 fl. oz.	91	34
50% American Cyanamid 12009	8 fl. oz.	95	40
50% Strobane	2 lbs.	76	34
25% G-22870	16 fl. oz.	99	90
25% lindane	1 lb.	97	37
L.S.D. at 5% level		13	
L.S.D. at 1% level		18	
Check	—	(217 aphids per terminal)	

under field conditions. It is also apparent that most of these have very little residual activity against this species. Even though sprays may be thoroughly applied as they were in the present instances the aphid populations may soon return to the levels of untreated trees. A material such as parathion which exhibits residual activity against pests like the codling moth and plum curculio has no more action in this respect than does TEPP. This is probably due in large measure to the habit of the aphids of constantly moving to and secreting themselves in the growing tips of terminals. Thus the newly unfolding leaves would have no residue and would be unprotected. The successful use of the strictly contact type of insecticide requires two or more applications at 7 to 10 day intervals for situations where aphid populations are on the upsurge.

Results with TEPP and parathion were variable over the 3-year period of this study. Thus in 1952 and 1954 these materials at recommended dosages gave less than 90 per cent reduction at 48 hours although results were better in 1953. In the case of TEPP both 20 per cent and 40 per cent formulations were tested and found to perform equally well on the basis of active ingredient dosage. The writers believe that temperature and wind conditions during and after spraying may influence the kill with this product by affecting the degree of coverage and the amount of fumigant action. Nicotine sulfate has long been known to give quite variable results against the apple aphid. Among the other non-systemic materials that were tested in all 3 years, malathion, lindane and Chlorthion gave consistently good immediate kills of aphids. Chlorthion was effective at $\frac{1}{2}$ to $\frac{1}{4}$ pound of 25 per cent wettable powder per 100 gallons.

The systemic insecticides were the most effective aphicides of all those tested and particularly from the commercial standpoint. Thus a sufficient degree of control might be obtained with one application of the material and with the kind of incomplete spray coverage which is typical of most practical spraying efforts. Under the conditions of the tests reported here demeton gave consistently good immediate kills with dosages as low as $\frac{1}{2}$ to 1 ounce of active ingredient per 100 gallons. By increasing the dosage, the length of residual effectiveness was prolonged up to a period of 3 weeks at 4 ounces of active (1 pint of 21.2 per cent emulsifiable). Further testing is needed to determine practical concentrations for the varied conditions encountered in commercial spraying. It was observed that the reinfestation of demeton-treated trees originated almost exclusively from winged females presumably migrating into the plots from infested trees nearby. These females were observed in small numbers a few days after treatment but no colonies were established for a week or more depending upon the dosage used.

Of the other systemics tested Meta-Systox (at twice the dosage used for demeton), Isolan and G-22870 appeared equal to demeton in initial kill and residual activity. Am. Cyanamid 12008 and 12009 and OS-2046 had shorter periods of activity than the foregoing.

The data shown here and observations on commercial applications of demeton indicate that this material and chemicals of similar characteristics will enable fruit growers to obtain more satisfactory control of the apple aphid than has been possible with such products as TEPP, malathion, parathion and nicotine sulfate. It seems probable that a systemic insecticide with short residual activity, such as OS-2046, might give satisfactory immediate control of aphids where thorough coverage and good control would be impossible with a product possessing only contact activity.

SUMMARY.—Twenty insecticides were evaluated for summer control of the apple aphid in tests made in 1952, 1953 and 1954. A number of materials were found to be quite toxic to this insect but most of them had little or no residual activity and aphid populations resumed development a few days after treatment. Included in this group were TEPP, parathion, malathion, Chlorthion, Diazinon, lindane and nicotine sulfate. Some of the systemic insecticides were very effective in immediate kill and in addition prevented reinfestation for a period of up to 3 weeks. Demeton, Meta-Systox, Isolan and G-22870 were very effective in this respect.

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Field Screening Tests with Various Materials Against the European Brown Snail on Citrus in California[1]

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Calcium arsenate-bran baits have been used extensively in citrus groves in southern California to control the European brown snail, *Helix aspersa* Müller. These baits have usually been formulated in the ratio of 1 part calcium arsenate to 16 parts bran, as originally suggested by Basinger (1923). More recently, metaldehyde has been included as an ingredient in commercially prepared arsenical-bran snail baits (Lange & MacLeod 1941).

Although the degree of snail control obtained through the use of arsenical baits with or without metaldehyde has been relatively satisfactory, there are certain objections to the continued use of arsenical materials because of phytotoxicity factors and the possibility of soil contamination. These materials are also ineffective against immature stages of snails that are feeding in the trees and are not attracted to ground-distributed baits. Evaluation of some of the newer toxicants as snailicides therefore seemed desirable, and a screening program was undertaken in the spring of 1954.

It is the purpose of this paper to report the results obtained in field screening tests of 32 compounds and mixtures as possible snail toxicants, and to present results obtained in subsequent experiments with the one material that appeared to be unusually effective against snails in the screening trials.

Materials and Methods.—One lemon grove and three Valencia orange groves heavily infested with snails near Escondido, San Diego County, California, where snails are a recurrent problem on citrus, were selected for the tests. In this area most citrus groves are noncultivated and are irrigated by sprinklers. These cultural practices in combination with the morning fogs that frequently envelop this area during the late winter and spring months favor snail development

The materials selected for screening were tested against snails in the form of baits in which bran was used as the substrate. In formulating each bait the desired amounts of bran and toxicant were placed in a ball mill and milled for 1 hour. The dry-mixed bait was then stored in a moisture-proof bag until needed for field use. Just prior to application during a period of favorable to maximum snail activity, enough water was added to a 1-pound lot of dry bait to form a crumbly mash, and this amount of moistened bait was broadcast into the snail-infested tree. Single trees without replication were used in the screening trials. Mortality counts were obtained from 10 to 16 days after treatment. All dead and live snails on the ground under the treated trees and about 3 feet outside the skirts of the trees were counted and recorded. The live snails remaining on the trees were also counted. To ensure more accurate mortality counts, the ground under and around the trees was raked prior to treatment to remove fallen leaves and empty snail shells.

Upon completion of the screening tests, two experiments were undertaken with Isolan,[3] the only material that had demonstrated particular promise in the screening tests. For these experiments the same formulation and data-gathering techniques were employed as outlined above. There were, however, modifications in methods of application of materials.

Table 1.—Effect of different toxicants used in bran bait in field screening tests for control of the European brown snail on Valencia orange trees.

Toxicant	Snail Mortality per Tree After Bait Treatment			
	Bran 99.5% Toxicant 0.5%	Bran 98.0% Toxicant 2.0%	Bran 92.0% Toxicant 8.0%	Bran 95.5% Toxicant 2.0% Metaldehyde 2.5%
DDT	0	0	36	844
Heptachlor	0	24	36	727
Isolan	734	852	374	630
Dieldrin	0	0	0	644
Strobane	—	26	216	624
Compound A-42[a]	0	0	31	352
BHC	37	157	189	440
Potasan	39	85	77	238
Prolan	0	0	0	389
Toxaphene	0	10	173	898
Aldrin	—	0	0	577
Diazinon	0	0	75	551
Endrin	13	0	42	468
Isodrin	61	0	0	823
Parathion	149	207	100	856
Chlorthion	25	111	48	470
Malathion	0	10	61	387
TDE	17	10	22	628
Perthane	0	0	15	720
Chlordane	0	78	0	714
Methoxychlor	0	78	30	714
Control[b]				427

[a] Arsenomethane AS-1, 2 disulfide; supplied by Theodore Riedeburg Associates, New York 17, N. Y.

[b] Commercial pelleted bran bait containing 6.75 per cent tricalcium arsenate and 1.5 per cent metaldehyde.

In the first of these tests, Isolan was used alone and in combination with other additives in an effort to establish a working range for further experimentation. Three methods of bait application were used: 1) peripheral application, in which the bait was scattered on the ground in an annular band about 1 foot wide outside and around the skirt of the tree; 2) trunk application, in which the bait was distributed on the ground under the tree in an annular band approximately 1 foot wide and about 6 inches from the tree trunk; and 3) broadcast application, in which the bait was tossed into the upper portion of the

[1] Paper No. 866, University of California Citrus Experiment Station, Riverside, California. Accepted for publication April 15, 1955.

[2] The writers wish to express their appreciation to Mr. A. A. Church, Agricultural Inspector, San Diego County, California, for obtaining suitable experimental sites; and to Messrs. G. F. Wood, C. H. Musgrove, and O. L. Wolfe of the Department of Entomology, University of California, Riverside, for assistance in obtaining the data.

[3] Supplied by Geigy Agricultural Chemicals Division of Geigy Chemical Corporation, Bayonne, New Jersey.

Table 2.—Effect of different toxicants used in bran bait in field screening tests for control of the European brown snail on lemon trees.

Toxicant	Per Cent Toxicant in Bran Bait	Snail Mortality per Tree After Bait Treatment: Toxicant Alone in Bran Bait	Snail Mortality per Tree After Bait Treatment: Toxicant with 1.5% Metaldehyde Included in Bait
Isolan	0.25	221	455
	0.50	539	740
	1.00	766	—
Compound G-341[a]	0.25	80	336
	0.50	187	362
	1.00	490	—
Compound G-339[a]	0.50	—	159
	1.00	20	249
Pyrolan	0.50	—	234
	1.00	111	642
Holcomb compound 326	0.50	—	113
	1.00	23	74
Compound 1269[b]	0.50	—	171
	1.00	42	124
Compound 2066[b]	0.50	—	284
	1.00	184	187
Nabam	0.50	—	97
	1.00	41	99
Diphenyl	0.50	—	98
	1.00	53	145
Diphenyl methane	0.50	—	197
	1.00	22	191
Diphenyl ethane	0.50	—	159
	1.00	—	125
Metaldehyde	1.50	73	
	2.00	234	
	2.50	660	
Control[c]		631	

[a] Compound G-341 is 1-ethyl-3-methyl-pyrazolyl-(5)-dimethyl carbamate and Compound G-339 is 3,4-dichlorophenyl-trichloro-methylcarbinylmethyl cellosolve carbonate; supplied by Geigy Agricultural Chemicals Division of Geigy Chemical Corporation, Bayonne, N. J.

[b] Compound 1269 is 2,4,5-trichlorophenylthionophosphate, and Compound 2066 is Diels-Alder addition product of allyl chloride and hexachlorocyclopentadiene; supplied by General Chemical Division, Allied Chemical and Dye Corp., 40 Rector Street, New York 6, N. Y.

[c] Commercial pelleted bran bait containing 6.75 per cent tricalcium arsenate and 1.5 per cent metaldehyde.

tree from various points around the tree and thus allowed to disperse evenly to the ground under the tree.

At the time of the second experiment with Isolan the absence of morning fog and the warm, dry conditions that prevailed made an irrigation necessary prior to treatment to induce snail activity. In this test Isolan was also used as a spray treatment. Conventional citrus spray equipment was used to apply a full-coverage spray. The remainder of the experimental block was treated with bran baits. All treatments were replicated three times.

RESULTS AND DISCUSSION.—The results obtained in the field screening tests are presented in tables 1 and 2. These data indicate that Isolan was considerably more toxic than any of the other materials tested against snails. It will be noted that the inclusion of 2.5 per cent metaldehyde in any of the baits greatly increased their toxicity (Table 1), but that 2.5 per cent metaldehyde alone was highly effective (Table 2).

A moderate kill was obtained with the bait containing 1.0 per cent Compound G-341 (Table 2). Although not evidenced by the data in table 2, the 111 snails killed by the bait containing 1.0 per cent Pyrolan represented an appreciable number of the original population infesting the tree treated with this material.

The remaining materials listed in tables 1 and 2 were ineffective against snails except for Strobane, BHC, toxaphene, parathion, and Compound 2066, all of which demonstrated measurable toxicity.

The appreciably large numbers of dead snails under the trees treated with tricalcium arsenate-metaldehyde bait (Table 3) indicate that this bait was superior to any of the other formulations utilized in this experiment. However, the commercially prepared tricalcium arsenate-metaldehyde bait which served as the control treatment in all the experiments was pelleted and may have remained attractive to the snails for a somewhat longer period than the experimental formulations.

The data presented in table 3 show that all baits containing Isolan gave some measure of snail control. The moderate number of snails killed by baits containing 0.5 per cent Isolan gave an indication as to the dosage range that would be most suitable in further studies.

Total kills resulting from the three methods of baiting used in the experiment suggest that there was little difference in the effectiveness of peripheral and broadcast applications. Baits applied to the ground in an annular

Table 3.—Effect of different methods of application of various bran baits containing Isolan on control of the European brown snail on Valencia orange trees.

Toxicant	Per Cent Toxicant in Bran	Snail Mortality: Per Tree: Peripheral Application	Snail Mortality: Per Tree: Trunk Application	Snail Mortality: Per Tree: Broadcast Application	Snail Mortality: Per Treatment
Isolan	0.125	61	70	214	345
	0.25	355	246	302	903
	0.50	955	526	932	2413
	1.00	633	351	705	1689
Isolan +metaldehyde	0.0625 + 1.50	652	226	542	1420
Isolan +metaldehyde	0.125 + 1.50	528	191	426	1145
Isolan +metaldehyde	0.25 + 1.50	237	347	406	990
Isolan +calcium arsenate	0.25 + 6.75	1259	587	1265	3111
Isolan +molasses	0.25 + 5.00	672	265	555	1492
Isolan +glycerine	0.25 + 5.00	190	386	382	958
Control[a]		1843	1475	1416	4734

[a] Commercial pelleted bran bait containing 6.75 per cent tricalcium arsenate and 1.5 per cent metaldehyde.

Table 4.—Results of treatments with Isolan sprays and various baits for control of the European brown snail on Valencia orange trees.

Toxicant	Spray Treatment: Pint Toxicant per 100 Gal.	Spray Treatment: Snail Mortality, Average Per Cent per Tree	Bait Treatment: Per Cent Toxicant in Bran	Bait Treatment: Snail Mortality, Average Per Cent per Tree
Isolan	0.25	93.2	0.50	87.8
	0.50	95.6	0.75	82.9
	1.00	95.9	1.00	88.5
Isolan +metaldehyde			0.25 } 1.50	95.5
Isolan +metaldehyde			0.50 } 1.50	92.7
Isolan +calcium arsenate			0.25 } 2.50	91.1
Control[a]				92.0

[a] Commercial pelleted bran bait containing 6.75 per cent tricalcium arsenate and 1.5 per cent metaldehyde.

area under the tree, near the trunk, were less effective.

As a spray, Isolan appeared to be unusually effective against the European brown snail (Table 4). The effectiveness of these spray treatments against snails in all stages of development is noteworthy, since earlier efforts to use sprays for snail control had not been entirely successful. The most effective spray treatment currently available, a combination of tartar emetic and sugar, which was developed and used for snail control by Orange County agricultural workers and reported by Lewis & LaFollette (1942), is highly toxic to immature stages of snails but fails to kill a significant proportion of the adults.

Favorable control was obtained with Isolan-bran baits (Table 4). With the exception of the bait containing 0.75 per cent Isolan, all treatments appeared to give control similar to that obtained with the standard tricalcium arsenate-metaldehyde bran bait.

SUMMARY.—Of 32 chemicals and mixtures used in field screening tests against the European brown snail, *Helix aspersa* Müller, Isolan appeared to be the most effective. Compound G-341 and Pyrolan were moderately effective. The remaining chemicals and mixtures had little or no toxic effect against snails.

Application of the baits to the ground in a peripheral band outside and around the skirts of the trees, and broadcasting of the baits into the trees, were equally effective methods of bait application and were more successful than baiting an annular area on the ground near the trunk.

Experiments with baits and sprays formulated with Isolan gave encouraging results against the European brown snail. Further investigations will be necessary, however, to evaluate the practical utility of this chemical against snails.

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Further Studies on the Effects of Soil Treatments with Insecticides on Residues and Fruit Quality of Strawberries[1]

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In an earlier paper, Gyrisco & Burrage (1954) indicated that off-flavors and odors were detected in the fruit of strawberries of the variety Sparkle, grown on certain soils which had been treated previous to planting with several different insecticides for the control of white grubs. Only fruit grown on soil treated with chlordane or lead arsenate gave no off-flavors or odors in these experiments. When unnatural tastes or odors were detected they were found to be stronger in fruit processed with heat than in fresh, or cold processed fruit, but in all cases these off-flavors were not objectionable.

Since off-flavors and odors of various plant products appear to be dependent on location, soil type, soil drainage and environmental conditions as well as processing with heat, it was believed worthwhile to initiate further work on the study of off-flavors and odors of the fruit from strawberries grown at a new location on a different soil type using both quick freezing and jamming methods of processing. Therefore, in 1952, an experiment was begun in Wayne County on Palmyra gravelly loam soil of high fertility which had been in sod for a number of years.

After the soil had been plowed, disked, fertilized and well fitted for planting, a complete randomized block experiment was laid out in which the plots were 10 feet by 15 feet in size, replicated 3 times and were separated from each other by a border area 3 feet wide surrounding each plot.

Aldrin, dieldrin, heptachlor and lindane dusts prepared from proprietary wettable powders diluted with pyrophyllite were applied to the soil on May 14, 1952, each at three concentrations as indicated in table 1, to the various plots by means of a hand-operated fertilizer spreader. Each insecticide was then well mixed with the upper 2 to 3 inches of soil by raking. Strawberry plants of the variety Sparkle were then set out in three rows 3 feet apart and

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Table 1.—Mean scores given by 43 judges in flavor and odor tests of fresh-frozen strawberry fruit from plots in which the soil had been treated with insecticides just prior to setting of the plants in the field.[a]

Insecticide	Pounds of Toxicant per Acre	Mean Score[b]	
		Odor	Flavor
Aldrin	1.0	10.1	9.7
	2.0	9.8	9.7
	4.0	9.9	9.5
Control	None	9.9	9.9
		n.s.	n.s.[c]
Dieldrin	1.0	9.8	9.6
	2.0	9.8	9.5
	4.0	9.7	9.7
Control	None	10.0	10.00
		n.s.	n.s.
Heptachlor	1.0	9.9	9.9
	2.0	9.9	9.7
	4.0	9.9	9.5
Control	None	9.9	9.9
		n.s.	n.s.
Lindane	1.0	9.9	9.7
	2.0	9.9	9.5
	4.0	9.8	9.5
Control	None	10.0	10.0
		n.s.	n.s.

[a] The insecticides were applied May 14, 1952, and the fruit was frozen in June 1953 and judged October 30, November 4 and 19, 1953.
[b] A score of 10 indicates natural flavor or odor; any score less than 10 indicates a degree of off-flavor or odor.
[c] n.s. equals no significant differences.

18 inches apart within each row. During the summer of 1952 while the plants were becoming established, they were maintained free of weeds by hoeing and all blooms were removed. After the first heavy frost had terminated plant growth, the plants were heavily mulched with oat straw.

In late June 1953, fruit was picked from all of the plots, composited within treatments, and subsampled for freezing. Each lot was cleaned, treated with 1½ cups of granulated sugar per quart of berries, placed in one-quart freezer-type cartons and quick frozen for taste testing at a later date. Part of the frozen berries from each treatment were retained for chemical analysis and bioassay for any possible insecticide residues. On July 3, a second picking of fruit was made in all of the plots and after compositing the various replicates, the fruit was subsampled, cleaned and processed as jam using 1½ pounds of sugar to each quart of strawberries and adding ¼ bottle of "Certo" fruit pectin and ⅛ cup of lemon juice to each of such lots.

On October 30, November 4 and 9, the fresh-frozen fruit was sampled for flavor and odor by panels of 13, 14 and 16 experienced judges chosen from the Department of Entomology of the New York State College of Agriculture and the Department of Food and Nutrition of the New York State College of Home Economics at Cornell University. The testing was conducted using a multiple comparison method, with an unknown check sample in the comparison and a known check sample as a reference standard. By the end of the three judging sessions, fruit from each treatment had been evaluated by 43 experienced judges for flavor and odor in a manner indicated in the earlier paper (Gyrisco & Burrage 1954). These data are shown in table 1.

From April 14, 1954 to May 3, 1954, all of the jammed fruit was judged twice by 21 experienced judges for flavor and odor. The results are presented in table 2.

All the data were analyzed by the analysis of variance method using the remainder term to test significance between the unknown control sample and each of the treated samples. No comparison was made between two treatments because the evaluation was designed for a comparison between each sample and its unknown control. Since it is more hazardous to say with flavor and odor testing that there is no difference than it is to say that there is a difference, results should be evaluated at the 0.1 level of significance rather than at 0.05 as is often the case with control-type experiments using insecticides. However, as is shown in table 2, the one treatment showing a difference at the 0.1 level of significance was also significant at the 0.01 level.

Portions of all of the samples of fresh-frozen fruit including those from the control plots were analyzed for any possible residues using a bioassay method of analysis similar to the one proposed by Olson (1954) in which a selected wild strain of red-eyed *Drosophila melanogaster* which had been raised and inbred for a number of years at Cornell University was fed directly on the macerated fruit in three separate trials. The bioassay method of analysis using *Drosophila* was found to be most sensitive and reliable in the cases of aldrin, dieldrin or heptachlor

Table 2.—Mean scores given by 21 judges in flavor and odor tests of jammed strawberry fruit from plots in which the soil had been treated with insecticides prior to planting of strawberry plants.[a] Newark, N. Y.

Insecticide	Pounds of Toxicant per Acre	Mean Score[b]	
		Odor	Flavor
Aldrin	1.0	9.5	8.0
	2.0	9.8	8.2
	4.0	9.5	8.6
Control	None	10.0	9.9
		n.s.[c]	L.S.D. 0.332 at 0.1 0.825 at 0.01
Dieldrin	1.0	9.5	9.1
	2.0	9.8	9.5
	4.0	9.8	9.8
Control	None	9.9	9.8
		n.s.	n.s.
Heptachlor	1.0	9.8	9.6
	2.0	9.9	9.6
	4.0	9.8	9.5
Control	None	10.0	10.0
		n.s.	n.s.
Lindane	1.0	9.8	9.2
	2.0	9.8	9.6
	4.0	9.8	8.9
Control	None	10.0	9.8
		n.s.	n.s.

[a] The authors are indebted to Valerie Gyrisco who cleaned and processed the fruit and to Anna Willman who prepared all the samples for judging. Fruit made into jam July 4, 1953 and judged April 14, 1954 to May 3, 1954.
[b] and [c] Same as in table 1.

Table 3.—Residues found by chemical analysis[a] of fresh frozen strawberries processed from fruit grown on soil treated with insecticides prior to planting. Newark, N. Y.

Insecticide	Pounds of Toxicant per Acre	Residue in p.p.m. Corrected for Control
Aldrin	1.0	0.005
	1.0	0.003
	1.0	−0.001
	2.0	0.009
	2.0	0.008
	2.0	0.015
	4.0	0.030
	4.0	0.024
	4.0	0.011
Heptachlor	1.0	0.000
	1.0	0.013
	1.0	0.014
	2.0	0.016
	2.0	0.015
	4.0	0.019
	4.0	0.021
	4.0	0.018
Chlordane	12.0	−0.005
(Oswego Co. Exp.)	12.0	0.001

[a] The authors are indebted to B. Hilton for conducting the chemical analysis of the samples.

and least sensitive and reliable in the case of lindane. (See Table 4.)

Other portions of fresh-frozen fruit from the aldrin- or heptachlor-treated plots at all three concentrations of active ingredients were analyzed chemically for residues using the phenyl azide method (Danish & Lidov 1950) in the case of aldrin and the Polen & Silverman method (1952), modified, for the fruit from the heptachlor-treated plots. These data are given in table 3. Fresh-frozen fruit from the chlordane treated plots in Oswego County (see Gyrisco & Burrage 1954) was analyzed chemically also for residues using the Davidow method (Davidow 1950) of analysis.

Table 4.—Residues found by bioassay[a] in fresh frozen strawberries from plots whose soil was treated with several insecticides prior to planting. Newark, N.Y.

Insecticide	Pounds of Toxicant per Acre	Residue in p.p.m. (Bioassay)[b]
Aldrin	1.0	0.1
	2.0	0.1
	4.0	0.1
Control	None	0.1
Dieldrin	1.0	0.1
	2.0	0.1
	4.0	0.1
Control	None	0.1
Heptachlor	1.0	0.1
	2.0	0.1
	4.0	0.1
Control	None	0.1
Lindane	1.0	0.2
	2.0	0.2
	4.0	0.2
Control	None	0.2

[a] The authors thank R. G. Blenk for conducting the bioassay for residues.
[b] Sensitivity of analytical method: For aldrin, dieledrin and heptachlor, 0.1 p.p.m. For lindane, 0.2 p.p.m.

Discussion.—None of the samples of fruit from any of the treatments or methods of preparation were judged to be off-odor or significantly different in odor from their controls or untreated standards.

All of the samples of fruit except those from the aldrin treated plots were judged to be satisfactory in flavor. The fresh frozen fruit from all of the aldrin-treated plots also was judged to be satisfactory in flavor but the jammed fruit from all three concentrations of aldrin-treated soil was found to be significantly off-flavor being judged as "flavor probably off" to "flavor obviously off." While the flavors of the jams from fruit of the aldrin-treated plots were found all to be significantly off-flavored, in no cases were they considered objectionable by the judges. These data on off-flavors with aldrin of fruit processed with heat are in agreement with those reported earlier (Gyrisco & Burrage 1954). However, with lindane or dieldrin soil treatment no unnatural flavors of the fruit were found as was the case with them under certain methods of preparation reported earlier. Fruit from heptachlor-treated soil, not tested previously, also was judged satisfactory in flavor.

Bioassay of the samples disclosed no residues of aldrin, dieldrin or heptachlor which exceeded 0.1 p. p. m. or were significantly different from the check. Lindane was probably of the same order of magnitude. Chemical analysis showed no residues to be present in amounts as great as 0.1 p. p. m. and would in no case exceed tentative tolerances established for them by the Food and Drug Administration.

Summary.—In 1952, an experiment was laid out in Wayne County, New York on Palmyra gravelly loam soil which was treated with 1, 2 or 4 pounds of aldrin, dieldrin, lindane or heptachlor per acre just prior to setting out strawberry plants of the variety, Sparkle. Fresh-frozen fruit and jam prepared from fruit of these plots were judged in 1953 and 1954 for flavor and odor by a panel of selected, experienced judges of the New York State Colleges of Home Economics and Agriculture at Cornell University.

The odor of all the fruit was judged to be satisfactory. The flavor of all of the fresh-frozen fruit was judged to be satisfactory. The flavor of the jam prepared from fruit grown on all the concentrations of aldrin-treated plots was found to be significantly off-flavor although not objectionable. Fruit from the heptachlor, lindane, or dieldrin plots with both methods of processing was found to be satisfactory in flavor and no different from their untreated controls.

Chemical and bioassay of the fresh frozen-fruit disclosed no residues that equaled or exceeded 0.1 p. p. m.

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The Effect of Ingredients in Insecticides on the Behavior of the Japanese Beetle[1]

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Hadley & Hawley (1934) call attention to the fact that although the Japanese beetle, *Popillia japonica* Newman, is known to feed on approximately 260 different plants, it shows a definite preference for certain ones. For example, grape and raspberry leaves are reduced to skeletons while dewberry and gooseberry leaves are left unharmed. The ecological factors involved in the feeding of the Japanese beetle are determined largely by attractant and repellent substances in the plants on which the beetle feeds.

While studying the mortality of beetles in corn fields treated with DDT it was noted that there were apparently more beetles feeding in the fields the day after the insecticide had been applied than before. The apparent influx of beetles into treated fields suggested that their feeding habits were influenced by the insecticide or some ingredient of the insecticide applied to the foliage. In the summers of 1950 and 1951 tests were made with a number of solvents, emulsifiers, oils, and insecticides for attractant or repellent qualities. The purpose of these experiments was to determine if a correlation could be shown between the ingredients of insecticides and a positive or negative response by the Japanese beetle when exposed to the materials.

1950 TESTS.—*Methods.*—In July 1950, six batteries of standard Japanese beetle traps were placed in a large pasture. Each battery was composed of 80 traps, subdivided into 4 replicates of 20 traps. Each replicate was composed of 18 traps containing a test material and two check traps, one containing a standard attractant the other an empty bait bottle. The replicates were arranged in 8 rows of 10 traps with a 10-foot interval between traps. Each test material was moved to a new position within the battery daily. Forty cubic centimeters of the solution to be tested were placed in a standard bait bottle, a cotton wick inserted, and the bottle mounted in a Japanese beetle trap. A quart Mason jar attached beneath the trap collected all beetles that entered. The attractant or repellent value of the materials was determined from the number of beetles collected from the traps. The ingredients were subjected to three treatments. These were as the commercial formulation alone, as the commercial formulation with a standard attractant[2] and as the commercial formulation with DDT.

Results.—The response of the Japanese beetle to the test materials was so erratic that it is difficult to determine the repellency or attractiveness, if any, of the materials. A study of the number of beetles caught in traps baited with the test materials in commercial formulations (Tables 1, 2, & 3) suggests that the solvents, odorless kerosene, So-Sol, benzene, xylene, Deobase, Shell Insecticide Base, Mistol, Ultrasene, regular run kerosene, fuel oil No. 2, Velsicol AR 50, Velsicol AR 55, Velsicol AR 60, Sovacide 544-B, Sovacide 544-C, Sun Solvent and Shell E-407 R were possibly repellent to the Japanese beetle. The insecticides, Vaponia D-43, lindane, BHC, methoxychlor, parathion and TDE were possibly repellent. These conclusions were based on a comparison of the percentages caught by the test ingredients as compared with an empty check trap. As the difference between materials is measured in 0.1 per cent the conclusions are supported by meager data.

With a standard attractant added to the commercial formulation test ingredients (Tables 1 & 2) the solvents, regular run kerosene, fuel oil No. 2, Velsicol AR 50, Velsicol AR 55, Velsicol AR 60, Sovacide 544-B, Sovacide 544-C, Sun Solvent and Shell E-407 were possibly repellent. It was reasoned that if a test material was neutral *per se* then the addition of the attractant would greatly increase the catch of beetles. If a test material was attractant *per se* the catch of beetles would be increased in proportion to the amount of standard attractant added. If a test material was repellent the catch of beetles would be reduced in proportion to the masking effect of the attractant. The Japanese beetle did not respond in such numbers as to indicate clearly a negative or positive behavior pattern when exposed to odorless kerosene, So-Sol. benzene, xylene, Deobase, Shell Insecticide Base, Ultrasene or to the insecticide Vaponia D-43. Since the proportion of standard attractant in the check was nine times that in the test material it would be expected that the check would attract the greatest number of beetles. These materials caught a high percentage of beetles when compared with the unbaited check. Whether this was the result of attractive qualities in the test ingredients or to the presence of the standard attractant could not be clearly determined.

[1] Scientific Article No. A502. Contribution No. 2612 of the Maryland Agricultural Experiment Station, Department of Entomology, University of Maryland, College Park. Project H-41. Adapted from a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Ohio State University. Accepted for publication April 15, 1955.

[2] Formula.—8 parts anethol, 1 part eugenol, and 1 part phenyl ethyl acetate. This was the formula of standard bait used in the Statewide Japanese Beetle Control Program for the summers of 1950 and 1951.

Table 1.—Japanese beetles trapped by test materials in batteries A, C, and E, 1950.

Test Material	Material: Alone, Battery A, Number	Alone, Battery A, Per Cent	With Standard Bait[a], Battery C, Number	With Standard Bait[a], Battery C, Per Cent	With DDT[b], Battery E, Number	With DDT[b], Battery E, Per Cent
Kerosene (regular run)[c]	972	0.6	20,764	2.9	940	0.7
Kerosene (odorless)[d]	1,303	.9	65,887	9.3	1,898	1.4
Fuel Oil No. 2[c]	919	.6	13,954	1.9	669	.5
So-Sol[e]	855	.5	48,076	6.8	480	.3
Velsicol AR 50[f]	742	.5	6,649	.9	442	.3
Velsicol AR 55[g]	746	.5	9,033	1.2	535	.4
Velsicol AR 60[h]	582	.4	6,678	.9	518	.3
Vapona D-43[i]	1,405	.9	52,463	7.4	1,016	.7
Benzene[j]	1,425	.9	79,371	11.3	845	.6
Xylene[j]	1,073	.7	63,377	9.0	862	.6
Deobase[k]	1,436	.9	74,840	10.6	860	.6
Sovacide s/v 544-B[l]	951	.6	8,969	1.2	781	.5
Sovacide s/v 544-C[m]	804	.5	6,389	.9	626	.4
Sun Solvent[n]	810	.5	3,904	.5	559	.4
Shell Insecticide Base[o]	1,809	1.5	52,716	7.5	1,690	1.2
Shell E-407 R[p]	1,320	.9	8,970	1.2	1,184	.8
Ultrasene[q]	2,168	1.5	55,667	7.9	1,867	1.4
Cyclohexanone	3,810	2.6	18,428	2.6	1,615	1.2
Standard bait[r]	118,464	82.3	99,170	14.1	110,000	83.5
Empty trap	2,196	1.5	5,793	.8	4,284	3.2
Totals	143,792	99.8	701,390	99.9	131,651	99.9

[a] Proportion: 4 cc. standard bait to 36 cc. test material.
[b] Proportion: 4 cc. of saturated solution of DDT (100%) in xylene to 36 cc. test material.
[c] Supplied by Wells Oil Co., College Park, Md.
[d] Supplied by Miller Chemical Co.
[e] Mineral Spirits (E-1) (aliphatic naphta). Supplied by Security Oil Co.
[f] Chiefly mono-dimethyl naphthalenes. Supplied by Shell Chemical Co.
[g] Methylated naphthene. Supplied by Shell Chemical Co.
[h] Chiefly di- and trimethylnaphthalenes. Supplied by Shell Chemical Co.
[i] DDT (4.5%) in mineral seal oil. Supplied by Shell Chemical Co.
[j] Supplied by Security Oil Co.
[k] Mineral oil. Supplied by Sonneborn Sons, Inc.
[l] Aromatic petroleum fraction Viscosity SSU 100° F. 41. Supplied by Socony-Vacuum Oil Co.
[m] Aromatic petroleum fraction Viscosity SSU 100° F. 34. Supplied by Socony-Vacuum Oil Co.
[n] Petroleum fraction initial boiling point 310° F. Supplied by Sun Oil Co.
[o] Deodorized kerosene. Supplied by Shell Chemical Co.
[p] Aromatic solvent, kerosene extract. Supplied by Shell Chemical Co.
[q] Refined paraffin in low viscosity petroleum fraction. Supplied by Atlantic Refining Co.
[r] Standard bait formula.—8 parts anethol, 1 part eugenol, 1 part phenyl ethyl acetate.

DDT was added to the commercial formulation in the proportion of 10 cc. of a saturated solution of DDT (made by dissolving 52 grams of technical DDT in 100 cc. of xylene) to 30 cc. of the test ingredient. The results are not conclusive. A comparison of the percentage of beetles caught by the test material containing DDT, with the empty check suggest that DDT has a repellent effect.

Nine of the newer organic insecticides were tested. If the insecticide was available in the commercial formulation as a liquid, 40 cc. of it was used to bait the trap. If the insecticide was available only in solid form, it was dissolved in xylene or mineral oil and the solution was tested. A study of the percentages in table 3 indicates that all the insecticides were slightly repellent except toxaphene and Pyrethrol Industrial Spray which were possibly slightly attractive.

1951 TESTS.—*Methods.*—In order to substantiate the results obtained in 1950, the materials that produced the strongest responses as attractants or repellents were selected and the tests were continued in 1951. The experiments were redesigned for treating data obtained by an analysis of variance. The ingredients tested were subjected to the same three treatments as in 1950. Each treatment was tested in 4 groups of 16 traps. Each group consisted of 15 traps containing test ingredients and an empty check trap. Each test ingredient was replicated four times with no ingredient occurring twice in the same groups. The groups were randomized at the beginning of the experiment and at weekly intervals throughout the period of the experiment.

Results.—Of the solvents tested in the commercial formulation (Table 4) Sun Solvent, Velsicol AR 50, Velsicol AR 60, kerosene, fuel oil No. 2, Shell Solvent E-407-R, Sovacide s/v 544-B, and xylene were possibly repellent.

A standard attractant was added to the commercial formulation in the proportion of 4 cc. of attractant to 36 cc. of the test ingredient. The purpose of adding the attractant was an attempt to clarify whatever attractant or repellent qualities existed. As would be expected, the Japanese beetles responded to the standard attractant in a most positive manner as shown by the increase in the number of beetles coming into the traps (Table 4). The response of the beetle was especially strong to Shell Insecticide Base and Deobase. The solvents, Velsicol AR 60, Velsicol AR 50, Shell Solvent E-407 R, fuel oil No. 2, Sovacide s/v 544-B, kerosene, Sova Spray No. 2, Shell

Table 2.—Japanese beetles trapped by test materials in batteries B and D, 1950.

Test Material	Material: Alone, Battery B, Number	Alone, Battery B, Per Cent	With Standard Bait, Battery D, Number
Mineral oil	1,848	1.0	20,271
Mineral oil (extra heavy)	2,176	1.2	15,069
Mistol (light)[a]	1,248	.7	
Atlas Span 85 (Batch 2097A)[b]	1,204	.7	
Atlas G-1276 (Batch 3945A)[c]	1,226	.7	18,491
Atlas Tween 20 (Batch 544A)[d]	1,435	.8	
Atlas Span 20 (Batch 2352A)[e]	3,262	1.9	
Triton X-100[f]	1,437	.8	20,035
Atlas G-1276 (Batch 3072)[g]	1,306	.7	
Atlox[h]	1,213	.7	21,826
Ethofat 242/25 (Lot 45)[i]	1,345	.7	12,668
Ethoneen S/15 (Lot 436)[j]	1,405	.8	15,816
Anqua O-2C (Lot 6297)[k]	2,436	1.4	2,867
Tenlo—400 (Griffin)[l]	1,728	1.0	
Nonisol—210[m]	3,146	1.7	
Unidentified material	3,442	2.0	
Methoxychlor[n]	2,056	1.2	
Lindane	3,197	1.8	
TDE[o]			1,122
Penphene[p]			1,755
Standard bait	130,565	77.4	84,033
Empty trap	2,965	1.7	2,755
Totals	168,639	99.9	216,208

[a] Fuel Oil Base, 6% or 12% DDT. Supplied by Shell Chemical Co.
[b] Sorbitan trioleate. Supplied by Atlas Powder Co.
[c] Polyoxyethylene sorbitol hexa ester of mixed resin and fatty acids. Supplied by Atlas Powder Co.
[d] Polyoxyethylene sorbitan monolaurate. Supplied by Atlas Powder Co.
[e] Sorbitan monolaurate. Supplied by Atlas Powder Co.
[f] Supplied by Rohm and Haas Co.
[g] Sorbitan trioleate. Supplied by Atlas Powder Co.
[h] Polyoxyethylene sorbitan. Supplied by Atlas Powder Co.
[i] Mono fatty or rosin acid esters of polyoxyethylene glycols. Supplied by Armour & Co.
[j] Tertiary amines. Supplied by Armour & Co.
[k] Dialkyl dimethylammonium chloride. Supplied by Armour & Co.
[l] A mixture of mahogany acid soaps and polyhyric alcohol. Supplied by Griffin Chemical Co.
[m] Polyethylene glycol dioleate. Supplied by Alrose Chemical Co.
[n] Supplied by E. I. duPont de Nemours & Co.
[o] Supplied by Rohm and Haas Co.
[p] Trade name of Pennsylvania Salt Manufacturing Co. for toxaphene.

Table 3.—Japanese beetles trapped by killing agents alone in battery F, 1950.

Test Material	Beetles Caught	
	Number	Per Cent
Toxaphene (50%)[a]	5,936	2.0
Toxaphene (tech.)[b]	4,983	1.7
Toxaphene (tech.)[c]	1,576	.5
Lindane[d]	1,453	.5
BHC (high gamma)	1,131	.3
BHC (11.2% gamma)[e]	1,243	.4
BHC (11.2% gamma)[e]	1,879	.6
Methoxychlor (50%)[f]	2,008	.6
Parathion (10%)[g]	629	.2
Parathion (10%)[h]	844	.2
Chlordane (tech.)[i]	2,126	.7
Chlordane (48%)[i]	2,749	.9
Chlordane (100%)[i]	4,336	1.4
Chlordane (100%)[i]	2,742	.9
Aldrin (23%)[j]	3,227	1.1
TDE[k]	1,916	.6
Penphene (EC-70)[l]	4,852	1.6
Pyrethrol Industrial Spray (0.29%)[m]	8,209	2.8
Standard bait	232,948	80.4
Empty trap	4,799	1.6
Totals	289,586	99.9

[a] Supplied by Hercules Powder Co.
[b] Ten gms. in 30 cc. mineral oil.
[c] Ten gms. in 30 cc. xylene.
[d] Ten gms. in 30 cc. xylene. Supplied by California Spray Chemical Corp.
[e] Ten gms. in 40 cc. xylene.
[f] Ten gms. in 40 cc. mineral oil.
[g] Ten gms. in 30 cc. xylene. Supplied by E. I. duPont de Nemours & Co.
[h] Ten cc. in 30 cc. xylene.
[i] 40 cc. Supplied by Shell Chemical Co.
[j] 10 cc. in 30 cc. xylene. Supplied by Shell Chemical Co.
[k] 40 cc. Supplied by Rohm and Haas.
[l] 40 cc. Supplied by Pennsylvania Salt Manufacturing Co.
[m] Pyrethrins, piperonyl butoxide and petroleum distillate. Supplied by McCormick & Co., Inc.

Table 4.—Japanese beetles trapped by test materials in 1951.

Test Material	Material		
	Alone Group A-D-C-K	With Standard Bait[a] Group C-F-J-M	With DDT[b] Group B-E-H-L
Sun Solvent	210	8,460	302
Velsicol AR 50	141	1,694	191
Velsicol AR 60	121	1,188	167
Kerosene	165	6,219	351
Fuel Oil No. 2	148	3,539	268
Shell Solvent (E-407-R)	210	2,803	238
Shell Insecticide Base	405	15,681	540
Shell Helix Superior Oil	415	7,333	392
Sovacide s/v 544-B	133	3,600	235
Xylene	275	7,358	346
Sova Spray No. 2[b]	460	7,255	408
Deobase	430	15,108	539
Atlas B-1276	276	3,915	423
Emcol H-74[c]	324	4,296	399
Emcol H-77[d]	270	6,257	390
Empty trap	458	879	421
L.S.D. at 5% level	155	725	186

[a] Proportions were the same as shown in footnotes to table 1. The materials were supplied by the same sources shown in footnotes to tables 1, 2, and 3, except as noted.
[b] Highly refined paraffinic oil. Supplied by Socony Vacuum Oil Co.
[c] A blend of polyoxyethylene esters of mono and di-carboxylic acids. Supplied by Emulsol Corp.
[d] A blend of polyoxyethylene esters of mono and di-carboxylic acids plus oil sulfonates. Supplied by Emulsol Corp.

Helix Superior oil, xylene and Sun Solvent were possibly repellent in combination with the standard attractant. The emulsifiers, Atlas E-1276, Emcol 74, and Emcol 77 were repellent in combination with the attractant.

DDT was added in the proportion of 10 cc. of a solution of 52 grams of technical DDT in 100 cc. of xylene i.e., a saturated solution, to 30 cc. of the commercial formulation of the test ingredient. Evidence was sought as to whether DDT was an attractant or a repellent in itself or whether it served as a synergist. The solvents, Velsicol AR 50, Velsicol AR 60, and Sovacide s/v 544-B, were significantly repellent (Table 4). The solvents, Shell Solvent E-407 R, Sun Solvent, kerosene, fuel oil No. 2, Shell Helix Superior oil, xylene, and Sova Spray No. 2 were possibly repellent. The emulsifiers Atlas G-1276 , Emcol H-74, and Emcol H-77 caught more beetles with DDT present but were not significantly attractive or repellent.

TESTS ON CANNING CORN.—*Methods.*—Field tests of the attractant or repellent value of ingredients of insecticides were made by treating canning corn in various stages of maturity during 1951. Plots of 100 plants were sprayed with test formulations. The first application was made when the ears were in early silk stage of development; later treatments were made in the mid- and late-silk stages of development. Six solvents and three emulsifiers were applied in various ratios. The number of beetles feeding in the check and test plots were counted before spraying and at 24-, 48-, and 72-hour intervals after the spray was applied.

Results.—An examination of the results of these field tests (Tables 5 & 6) showed the erratic behavior of the Japanese beetle. In plot tests B & D, there was a notable drop in beetle population as compared with the numbers in the check plots except in the plots treated with Shell Insecticide Base and Deobase where the beetle population remained relatively the same after treatment. This suggested these two materials were neither repellent nor attractive, but neutral.

The addition of DDT to the formulation had a seemingly repellent effect, at least the beetle population failed to show a notable increase after a period of 72 hours. Whether this was due to a repellent effect of the solvent, the DDT, or to a combination of both could not be determined.

The addition of an excessive amount of an emulsifier, Atlas G-1276, to the formulation resulted in a considerable reduction in beetle population in the plots treated with this formulation. The number of beetles involved was small but the evidence suggested that Atlas E-1276 was repellent.

SUMMARY.—The Japanese beetle is of great economic importance in Maryland; by feeding on the corn silk at the time of pollination it prevents the fertilization of the kernels and their subsequent development. To protect canning corn during this critical period of development it is customary to treat the corn with DDT. The large number of Japanese beetles observed in corn fields the day after treatment suggested that the DDT, or some

Table 5.—Japanese beetles trapped by test materials applied in corn field. (Series A, B & C.)

Material	Number of Beetles							
	Before Spraying	After Spraying[a] (Hrs.) 24	48	72	Before Spraying	After Spraying[b] (Hrs.) 24	48	72
1. Velsicol ZR 50	25	15	9	25	264	17		31
2. Velsicol AR 60	57	18	7	21	293	20		26
3. Sovacide s/v 544-B	48	19	4	14	319	10		0
Check on 1–3	73	84	62	60	69	74		103
4. Atlas G-1276	29	34	34	28	153	26		13
5. Emcol H-74	83	68	31	42	273	36		12
6. Emcol H-77	86	23	37	70	304	19		13
Check on 4–6	84	62	60	81	84	88		95
7. Shell Insecticide Base	58	53		171	438	84		135
8. Deobase	58	66		69	212	26		13
9. Helix Superior Oil	63	37		58	208	48		52
Check on 7–9	60	81		88	84	88		95

[a] Series B, sprayed August 3 with 1¼ pints test material to 3 gals. water. Corn in early- to mid-silk stage.
[b] Series A and C, sprayed August 4, 7, and 8. Corn in early- to mid-silk stage. Formulation: 3 gals. water and 1 pint test material, 27 grams 50% DDT wettable powder.

Table 6.—Japanese beetles trapped by test materials applied in corn field. (Series D & E).

Material	Number of Beetles							
	Before Spraying	After Spraying[a] (Hrs.) 24	48	72	Before Spraying	After Spraying[b] (Hrs.) 24	48	72
Velsicol AR 50	246	84	70	98	204	8	14	14
Velsicol AR 50 plus Atlas G-1276					204	6	16	12
Velsicol AR 60	214	58	222	42	204	10	14	54
Velsicol AR 60 plus Atlas G-1276					204	0	2	0
Sovacide s/v 544-B	274	57	2	0	204	70	58	16
Sovacide Atlas G-1276 plus Atlas G-1276	84	28	38	32	204	8	22	8
Emcol H-74	272	144	36	54				
Emcol H-77	276	118	16	2				
Shell Insecticide Base	520	416	228	184				
Deobase	294	252	212	162				
Helix Superior Oil	182	192	210	20				
Check	254	204	228	90	204	228	90	58

[a] Series D. Sprayed August 8 in mid- to late-silk stage with 1 pint test material to 2 gals. water.
[b] Series E. Sprayed August 10 in late-silk stage. Formulation: 2 gals. water and 1 pint test material; except 2 ounces of Atlas G-1276 added as shown.

ingredient of the formulation applied, was attracting the beetles to the field. To test the validity of this hypothesis a number of solvents, emulsifiers, oils, and insecticides were tested in a series of experiments in the summers of 1950 and 1951 for attractant or repellent qualities. The ingredients tested were subjected to three treatments, that is, as the commercial formulation alone, the commercial formulation with a standard attractant, and the commercial formulation with DDT.

The response of the Japanese beetle to the test materials was so erratic that it was difficult to determine the repellency or attractiveness, if any, of the materials. In general, the solvents, emulsifiers, and insecticides tested in the commercial formulation were repellent to the Japanese beetle. There was no evidence that any were strongly attractive to the beetle although a few, such as toxaphene and Pyrethrol Industrial Spray were possibly slightly attractive.

The addition of standard attractant to the commercial formulation seemingly masked the repellency of ingredients having a low order of repellency. However, the more repellent ingredients were not masked by the standard attractant and were avoided by the Japanese beetle.

The addition of DDT to the ingredients tested had little effect on the behavior of the Japanese beetle. The results of the trapping experiments do not support the hypothesis that Japanese beetles were attracted into corn fields by the presence of DDT in the insecticide. Field tests of the attractant and repellent qualities of ingredients of insecticides made by treating canning corn in various stages of maturity confirmed these results.

A study of the results indicates that the problem is extremely complex and that further tests are necessary before the exact effect of the test materials on the behavior of the Japanese beetle can be determined.

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Control of Hop Aphid and Two-spotted Spider Mite in Oregon[1]

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About 1891, the hop aphid, *Phorodon humuli* (Schr.), first made its appearance in the Pacific Northwest (Riley & Howard 1891) and since then has been a major insect pest of hops. The overwintering egg stage is passed on *Prunus* spp., the primary hosts. The eggs normally hatch in late April or early May and several generations are passed on foliage of *Prunus* before spring winged migrants are produced. About the end of May, migration to the summer host (hops) begins. This is usually completed by the end of June. Occasionally, egg hatching on prune may occur during warm periods in February. Prune foliage at this time is not developed and the aphids perish. When this happens, a later hatch of eggs may follow and migration to hops may be extended to the latter part of July. There are usually five or six generations of aphids on hops during the summer months. Fall migration back to prunes begins about the middle of September and continues through October.

Heavy aphid populations will devitalize the hop plants and contribute to lower yields. Also, the aphids tend to move into the hop cones during warm weather, where they feed and secrete honey dew. This supports the growth of sooty mold fungi which discolor the hop cones and lower their market value. For this reason, it is im-

[1] Technical paper No. 902 Oregon Agr. Expt. Station. Accepted for publication April 18, 1955.
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portant to effect aphid control early while hops are in the prebloom or bloom (burr) stage. Thus, aphids are prevented from entering cones and the threat of fungus damage is considerably reduced.

The hop aphid is favored in its development by cool moist conditions. Heavy populations may be encountered early in June, but they are frequently suppressed by warm dry weather in July and August. A sudden rise in temperatures in the hop yard to 100° F. will cause heavy mortality. However there are usually enough survivors for aphids to build up rapidly if favorable weather conditions prevail at harvest time in September.

The two-spotted spider mite, *Tetranychus telarius* (L.) has been a major hop pest in the Pacific Northwest since 1892 (Ewing 1914). In Oregon, the adult females overwinter on weeds, grasses and other perennials which remain green during the winter. Activity is resumed in the spring and eggs are deposited during April and May. Migration to hop plants begins late in July when wild hosts become unattractive. It is estimated that normally about nine generations of mites develop on hops during the summer months. The peak of population can be expected from the middle to the latter part of August.

In most instances, mites move from wild hosts to the lower portion of the hop plant. As the season advances, they move upward and infest the entire plant. However there have been instances when the top of the vine became infested before the bottom. Under these circumstances, it was believed that the mites were carried into the yard by air currents.

Warm dry weather conditions are commonly considered as most favorable for spider mite development. However, there have been occasions in which favorable conditions have prevailed but spider mites disappeared from hop plants about midseason. Since parasites and predators were not present in sufficient numbers to be responsible for this phenemonon, the population decline was probably caused by changes in the physiology of the plant.

REVIEW OF CONTROL MEASURES.—Quassia-whale oil soap sprays were developed by hop growers early in the history of hop aphid control. Riley & Howard (1891, 1892 a, b, c), Koebele (1893) and Washburn (1894) discredited the value of quassia sprays and recommended the use of kerosene emulsions. In spite of this disapproval, quassia remained popular with some hop growers as late as 1937.

Parker (1913) worked on the life history and control of hop aphids and indicated that nicotine sprays were replacing quassia and kerosene emulsion sprays. He reported that chemical residues of nicotine or whale oil soap could not be found when nearly ripe hops were sprayed with nicotine sulfate sprays.

During the period 1930–1936, hop growers developed dusting machinery and rapidly changed their aphid control program from spraying to dusting with nicotine. This dusting program remained standard until 1944 when a wartime scarcity of nicotine necessitated a hurried search for suitable substitutes. In attempts to conserve nicotine (Morrison *et al.* 1946) learned that 3 per cent nicotine dusts prepared from nicotine alkaloid were as efficient for hop aphid control as 4 per cent dusts prepared from nicotine sulfate.

Materials showing little promise during the 1944–1948 period included TDE, methoxychlor, toxaphene, chlordane, azobenzene, BHC, ryania, rotenone and pyrethrum. Results from the use of lethane dusts were erratic. Eight per cent DDT dusts were found to be toxic to the hop aphid. However, the rate of kill was slow and the rate of aphid recovery after DDT treatment was very rapid. BHC dusts (1 and 2 per cent gamma isomer) were very toxic to hop aphids but they contributed to an altered aroma of dried hop cones.

In 1947, field tests with HETP dusts gave erratic results. However, with improved formulations and the adoption of TEPP by the industry, a material was found which was very efficient for hop aphid control.

Parathion was tested for the first time in 1947 for control of the hop aphid and was found to be very effective. After additional field trials, chemical residue studies and brewing tests, parathion was recommended for hop aphid control (Every & Hoerner 1951). The results of the 1947 chemical analyses and brewing studies were confirmed by similar tests by the brewing industry in 1953.

Early recommendations for the control of the two-spotted spider mite (1892–1940) were reviewed by Morrison & Mote (1940). They also showed the value of DN dusts in experimental field trials. With additional work, which included residue analyses and brewing studies, Morrison & Price (1941) recommended DN dusts (dinitrocyclohexylphenol and its dicyclohexylamine salt) for spider mite control and gave details for improved dusting machinery. Later fields trials which attempted to combine nicotine and DN in one dust for control of both hop aphids and spider mites, resulted in the inactivation of both toxicants.

With the development of new acaricides, hop growers became interested in materials which would be effective against both hop aphids and spider mites. TEPP and parathion were recommended by Every & Hoerner in 1951. Aramite as recommended by Klostermeyer & Breakey (1951) in Washington was not favorably received by Oregon growers because of its tendency to injure the foliage of the Fuggles variety. Field tests with Ovotran dusts and sprays in 1952 showed that this material was very toxic to hop cones of all common varieties of hops. Three weeks were required for this injury to become noticeable.

STATUS OF HOP PEST CONTROL IN 1952.—By the end of the 1952 season, three materials of about equal effectiveness were recommended for hop aphid control. These were nicotine dusts (3 per cent prepared from nicotine alkaloid or 4 per cent from nicotine sulfate), 1 per cent TEPP or 1 per cent parathion dusts applied at the rate of 40 pounds per acre.

For red spider mite control 1 per cent TEPP or 1 per cent parathion dusts were about equal in effectiveness to DN dust D-4 or DN dust D-8 applied at the rate of 40 pounds per acre. The DN dusts were specific for control of spider mites and nicotine dusts were specific for hop aphids. Neither material was toxic to paratites or predators.

Although the phosphate insecticides (TEPP and parathion) were effective on both hop pests, they were also very toxic to their natural enemies. A high degree of initial control was accordingly necessary when the phosphate insecticides were used in order to prevent a rapid recovery

of the hop pests. In addition, TEPP dusts were effective only against the mobile forms of spider mites. Unless the applications were properly applied and well timed, four or more TEPP treatments each season were sometimes needed. Moreover, hop aphid control should be effective by the first week of July. Spider mite development usually occurs by late July or early August. One application of either of the phosphate insecticides often failed to adequately control both pests.

In 1952, many hop growers were either using airplanes for the application of pesticides or had converted to the use of air blast sprayers. With the use of spray equipment of this kind, there was considerable interest in the possible use of systemic insecticides.

Exploratory tests with demeton (0.2 and 0.4 pounds actual material per acre) were made with an air blast sprayer (using 100 gallons per acre) in 1952. Both dosages gave excellent control of the two spotted spider mite. Hop aphids were not present in the hop yard for evaluation of control. It was indicated from these trials that the degree of plant succulence at the time of treatment, could govern the efficiency of demeton for spider mite control.

1953 EXPERIMENTS.—Hop aphids and red spider mites were reared on hops in the greenhouse and cloth house for use as biological agents in tracing the movement of demeton through the hop plant. Various concentrations of demeton were applied to individual hop leaves. Hop aphids and red spider mites were caged on the treated leaves as well as leaves above and below the point of application. In other tests, demeton at various concentrations was applied to moist soil about the roots of hop plants. The movement of the insecticide was traced by caging hop aphids and spider mites on the foliage of these plants. It was indicated, by these preliminary trials, that demeton was not translocated from the treated foliage because kills were not obtained above or below the point of application. Although this could have been due to the low concentration of demeton, the results were later tentatively confirmed in field trials. When either the top or bottom half of individual hop plants was sprayed with demeton (1 to 4 oz./acre) kills were not observed above or below the point of application.

Greenhouse trials showed that when demeton was applied to the roots of hop plants, translocation was effected throughout the plant. Attempts to confirm this in the field were not successful. However the soil in these field trials was very dry and probably little demeton reached the hop root system. From the greenhouse trials, it was calculated that demeton at the rate of 1 oz. actual material per acre should be effective in the field against both hop aphids and red spider mites. In order to confirm this, a randomized set of field plots was established. Eight treatments with six replications of six hill plots were laid out according to the technique of Morrison (1940). The treatments included demeton (1, 2, 4 and 8 oz.), Diazinon (8 oz.), parathion (8 oz.) and schradan (1½ lbs.) actual material per acre. The systemic insecticides demeton and schradan were formulated as emulsion concentrates while parathion and Diazinon were prepared as 25 per cent wettable powders.

A Hudson Matador sprayer (15 gallons capacity) was used to apply the materials. Volume of the dilute spray per acre was held constant in all plots at 200 (2⅔ pt. per plant). The spray nozzle was placed at the end of a 5 foot extension rod in order to reach the top of the hop plants. Pressure was held at 10 p.s.i. in order to prevent spray drift. The sprays were applied in the early morning when there was little air movement as a further precaution against drift. The sprays were applied July 8 and 10 (46 days before harvest). At this time, hops were in the prebloom stage. Hop aphids were thinly distributed throughout the plots but were colonizing. Hop aphids from an early February egg hatch had perished but a later hatch was probably responsible for winged migrants in the hop yard late in July. Only an occasional red spider mite could be found on suckers of the hop plant on July 10. Mites in the check plots did not begin to develop in measurable numbers until after July 20. The results of this experiment were checked at intervals of 3, 20 and 33 days after materials were applied. No records were taken at harvest time because the grower had dusted the entire hop yard (including experimental plots) with 1 per cent TEPP by airplane 1 week before harvest.

In previous years, frequency distribution studies of hop aphids and red spider mites were made at weekly intervals throughout the growing season. A similar type of distribution was found for both species. By plotting the mean population per leaf against the percentage of leaves infested, it was found that a definite curvilinear relationship existed. This relationship could be best expressed by two regression lines—a gradual slope from 0 to 50 per cent and a steep slope from 50 to 100 per cent infested leaves. The accuracy of one unit of measurement was equal to the other in obtaining measurements of population. Since percentage leaves infested is more easily measured in the field, it was used to measure the performance of the 1953 experiments. Although population counts were taken three times during the growing season, the performance of the treatments in controlling hop pests is best shown in table 1 when counts were taken 33 days after materials were applied.

In addition to these experimental plots, three 48-hill plots were sprayed with demeton at the rate of 8 oz. actual material per acre. The timing of the application was varied so that hops were sprayed at 30, 15 and 5 days before harvest. Hops from these plots were picked, dried and

Table 1.—Effectiveness of insecticides on hop pests 33 days after treatment.

TREATMENT	ACTIVE INGREDIENT PER ACRE (OZ.)	PERCENTAGE OF LEAVES INFESTED	
		Hop Aphids	Red Spider Mites
Schradan	24	3.3	21.7
Diazinon	8	16.7	20.0
Parathion	8	25.0	15.0
Demeton	1	11.7	45.0
Demeton	2	15.0	40.0
Demeton	4	3.3	18.3
Demeton	8	3.3	3.3
Check	—	53.3	76.7
L.S.D. at 5% level		12.5	17.4
L.S.D. at 1% level		17.9	24.4

Table 2.—Summary of hop aphid control, Corvallis, Oregon. 1954.

Material	Active Ingredient per Acre (Oz.)	Percentage of Leaves Infested with Hop Aphids — August 4	11	18	25	30
Demeton	8	0	0	0	0	0
Schradan	24	0	0	0	17	11
Malathion	32	0	6	16	14	19
Meta-systox[a]	8	0	0	12	11	29
Check	—	86	86	95	91	84
L.S.D. at 5% level		6.18	7.7	10.6	10.8	15.3
L.S.D. at 1% level		8.4	6.5	14.7	15.0	21.2

[a] 0,0-dimethyl 0-2-ethylmercaptoethyl thiophosphate.

baled separately. Chemical analyses of these hops by the Department of Agricultural Chemistry of Oregon State College did not reveal any trace of demeton.

1954 EXPERIMENTS.—Further studies in the field were carried on in 1954. The field plot technique, method of application, and collection of data were similar to the 1953 methods. 1954 treatments consisted of demeton (8 oz.) schradan (1½ lbs) and malathion (2 lbs.) actual material per acre. The materials were applied July 27 and 28 when the Late Cluster variety of hops was in the late bloom stage. Aphids at this time were thinly scattered throughout the plots. Again an early February hatch of aphid eggs was observed. A later egg hatch probably was responsible for a late appearance of winged migrants in the hop yard. The summer of 1954 was cool and wet and red spider mites did not develop sufficiently to make measurements of population. The data were collected at intervals of 7, 14, 21, 28 and 33 days after the sprays were applied. Evaluation of the results are summarized in table 2.

In addition to the small replicated field trials, an experiment was made on a ¼-acre block of Fuggles hops in which demeton was applied through a sprinkler (perforated pipe) irrigation system. On July 23, after the hops were given 2 inches of irrigation, demeton was mixed in 40 gallons of water and siphoned into the irrigation system on the suction side of the pump. Regular checks made in this plot showed that all plants were free from aphids for the remainder of the season. This was an interval of 37 days from the time of treatment.

DISCUSSION AND CONCLUSIONS.—Good initial control of the hop aphid was obtained with all of the treatments used in the 1953–1954 experiments. Schradan (1½ lbs. and demeton (4 and 8 oz.) protected the crop for over a month. Meta-systox and malathion have not been fully evaluated against red spider mites but appear to offer only about 2 weeks protection from attacks by hop aphids. Of the materials tested, demeton at the rate of 8 oz. per acre offers most promise for control of both species of hop pests. Its initial rate of application will apparently govern the period of time in which hops are protected. The present results indicate that demeton could fill the need of the long sought single remedy for hop pest control.

Observations on predator control with demeton have been limited and inconclusive. Information of this kind is not readily collected from small plots. However, other phosphate insecticides are very toxic to both parasites and predators. It is likely that demeton as a contact material will also be toxic to the beneficial insects. Moreover, Ahmed *et al.* (1954) reported that many species of predators were killed after feeding on cotton aphids which had fed on demeton sprayed cotton foliage. However, if demeton would continue to perform as indicated in the 1953–1954 trials, the role of predators in controlling hop pests could be reduced to minor importance.

The application of demeton to hops by sprinkler irrigation systems offers considerable promise and fits readily into established agronomic practices. When applied in this manner, the need for costly spray equipment is eliminated and the toxic hazard of application is greatly reduced. The control of red spider mites on wild hosts in the hop yard could possibly be effected in this manner. This could result in added protection of hop plants in preventing them from becoming infested late in the season.

It was difficult to estimate how much demeton should be used when it was initially applied by a sprinkler irrigation system. The 24-ounce dosage (6¼ micrograms/sq. ft. leaf and soil area) was probably excessive. Gross (1900) estimated the leaf area of a hop plant at 120 sq. ft. but did not show the method of arriving at this figure. Morrison (1940) calculated the regression of the area of fresh hop leaves with their dry weight. The total dry weight of leaves from three mature hop plants was later measured. Their leaf area was calculated as 93, 92, and 103 sq. ft. (mean 96 sq. ft.) Since there are 680 hop plants per acre, the total leaf area of hops is calculated at 65,280 sq. ft. Eight ounces of actual demeton per acre (3¼ micrograms/sq. ft. leaf area) applied as a spray protected hop plants from pest attack for over 1 month. Accordingly 13 to 14 oz. (3½ micrograms/sq. ft. leaf and soil surface) should give comparable results.

It is necessary to make brewing tests and to obtain data on chemical residues before insecticides can be recommended for use by hop growers. In Oregon, the average yield of dried hops approximates 5 bales (1000 pounds) per acre. If all the demeton which was applied (8 oz.) would be found on the dried hops, the residue would approximate 500 p. p. m. By using ¼ pound of hops per barrel of beer (31½ gal.) the demeton residue would be reduced to about 0.48 p. p. m. However no demeton residues were found in dried hops which were sprayed with 8 oz. actual material 5 days before harvest. Therefore, it is not likely that demeton will contribute to a residue problem on hops. If no adverse data are collected from brewing tests, demeton can be safely recommended for hop pest control.

SUMMARY 1.—The bionomics and control of the two principal hop pests of Oregon, *Phorodon humuli* (Schr.), and *Tetranychus telarius* (L.) are reviewed. By the end of 1952, parathion, TEPP and nicotine dusts were recommended for hop aphid control. The organic phosphate and DN dusts were recommended for red spider mite control.

Since the organic phosphate dusts were quite toxic to the natural enemies of the hop pests, a high degree of control was needed in order to prevent a rapid rate of reinfestation. Although the organic phosphate materials were toxic to both species of pests, the timing of application was different. For this reason, more than one application was often needed if both pests threatened the hop crop.

Demeton was first tested in 1952 and studied more in-

tensively in 1953 and 1954. Light dosages of demeton (1 to 4 oz. actual material per acre) gave good control of both species of hop pests. Eight ounces of actual demeton has maintained control of both pests for a 33-day period. Of the materials tested, demeton appears to be superior to schradan, parathion, malathion, Diazinon, and Metasystox in affecting hop pest control.

The application of demeton to hops through a sprinkler irrigation system has been used successfully. The application of the material in this manner fits readily into established agronomic practices, eliminates the need for costly spray equipment, and reduces the toxic hazard of application.

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The Interrelations of Biological Control and Taxonomy[1]

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Taxonomists are sometimes regarded as a necessary evil, and I suspect that some folks regard them as just plain evil. For their part, taxonomists often appear to have a superiority complex about control workers. Today I shall speak on the thesis that the fields of taxonomy and biological control are abundantly interrelated, that they have much to gain from and to offer each other, and that there should be more, or more active, liaison between them. From no other part of economic entomology can the taxonomist learn so much and, conversely, in no other branch of economic entomology is taxonomy so vital as in biological control. Indeed, one could with considerable justification call biological-control workers "applied taxonomists."

I shall not attempt to differentiate between taxonomy and systematics, as some have done and perhaps would wish me to do. For the many taxonomists who have always had a broad outlook, the expressions "systematics" and "the new systematics" are simply taxonomy under new labels. Without laboring the point, I am considering taxonomy here in a broad and inclusive sense.

The fields of taxonomy and biological control have long been intertwined, almost complementary. Many taxonomists began their careers in or were assigned to biological control. The list of those who have contributed greatly in both fields is a long and distinguished one, including such names as L. O. Howard, Townsend, Tothill, Thompson, Muesebeck, Sellers, Webber, and many others. Such centers as the Gypsy Moth Laboratory of the old Bureau of Entomology and the Citrus Experiment Station at Riverside, California, have been fruitful training grounds for both taxonomists and biological-control workers.

CLOSER COOPERATION.—If there were a major theme for my discussion it would be this: There should be closer cooperation between taxonomy and biological control. True, there is a great deal of fine cooperation, and I would not for a moment wish to decry it. However, there is failure of many workers in one field to utilize to the the fullest the information and facilities of the other. My examples are chosen without malice or conscious aim, but with the hope that study of the past will reveal some pitfalls to avoid, some aims to strive for, some cooperation to encourage.

1. *Consultation before introduction of parasites from abroad.*—Consultation with taxonomists, or their participation in preliminary planning, could well be part of regular policy and routine before the institution of a biological-control project. Some mistakes might be avoided, some other leads suggested, or some difficulties pointed out. It must be admitted that taxonomists have made some

[1] Accepted for publication April 22, 1955. Presented at second Annual Meeting of the Entomological Society of America, Houston, Tex., December 6–9, 1954.

mistakes—and who has not?—even when consulted, although I might remark that mistakes are always more obvious in hindsight. Some errors, however, can be prevented by foresight.

In the early 1940's the attempted introduction from Uruguay and Argentina of the armyworm parasite *Archytas incertus* (Macq.) (=*piliventris* Van der Wulp) was discontinued when taxonomists reported that the species was already common in southern United States. Preliminary consultation would have prevented waste of time and effort. This example does have another side to it. Taxonomists universally and for years had considered *incertus* to be a common species ranging from southern United States to Argentina, but I observed recently that two species are involved. However, even had taxonomists known that at the time introductions were considered, it would still have been important to warn control workers of the existence of two such similar and easily confused species, possibly differing in effectiveness as parasites.

2. *Consultation before transfer of parasites from one part of the country to another.*—This consultation between biological-control workers and taxonomists may be even more important than that concerning introductions from abroad. Before we mix populations within a continent, we should make sure that we have before us the available information on closely related species, subspecies, and host relations. A recent example is the squash bug parasite of the eastern United States, *Trichopoda pennipes* (F.). For many years California specimens have also been identified as that species, although in California it does not attack *Anasa tristis* (Deg.), but parasitizes a pyrrhocorid bug, *Largus* (=*Euryophthalmus*). A few years ago, *pennipes* from the eastern States was introduced into the Pacific Northwest, and recently into California. Thus *pennipes* is being introduced where *pennipes* supposedly is already present.

Some may ask, "What difference does it make, if control results?" Perhaps none at the moment, but we may have lost our best chance to know what we are doing, to establish a sound understanding and scientific basis for our work. The relation and status of the eastern and western forms of *Trichopoda pennipes* are significant points for both taxonomists and biological-control workers. We should not make haste to take an irretrievable step before we try to ascertain the facts. Those responsible for planning should not be diverted from taking a long-range view and getting fundamental information before the natural situation is confused by mixing eastern and western strains—or species, or whatever they are. It is gratifying to learn that insectary studies on the problem are being carried on in California at the Riverside laboratory.

3. *Cooperation in the planning of surveys.*—As in the planning of introductions, taxonomists also have a place in the planning of surveys. Obviously, some kinds need no participating taxonomists. Other surveys may require advice, and some need considerable taxonomic assistance, the availability of which should be ascertained in advance, and which should be planned for and appropriated for if need be. Taxonomists may be able to suggest important considerations for the operation of the survey, such as possible confusion of species of parasites or of hosts.

4. *Preservation of samples.*—In the past, thousands of introduced or reared parasites have been released, but all too often, no series representative of those releases have been placed on file in museum collections. After some period of time surveys have been made and material has been reared for examination by taxonomists. Has the introduced parasite been recovered? If there is no reference material, one often can only ask, "What did you release?" True, there is a recorded identification, but ideas may change , taxonomists may differ in their opinions, misidentifications may have been made. And in difficult and complex groups, new species are continually being segregated from those once confidently thought to be well known.

A few examples will illustrate the situation. The ichneumonid *Collyria calcitrator* (Grav.), a parasite of the wheat stem sawfly, was introduced from Europe many years ago in some numbers. Later, when the sawfly became the subject of a large research program, the systematic unit of the Bureau of Entomology was asked for examples of the parasite. There were only three old specimens in the collection, all from Europe and without any connection with the introduction. In another instance, *Prospaltella smithi* Silvestri, an aphelinid parasite of the citrus blackfly, was introduced from southern Asia. No material from the original introduction is in the collection.

Parasites of the gypsy and other moths were introduced into New England by the thousands from 1906 into the 1930's. Until recently, when material from the old Gypsy Moth Laboratory was transferred to Washington, practically none had been deposited in the collection of the U. S. National Museum, which is the reference collection for taxonomic entomologists of the U. S. Department of Agriculture. For example:

Compsilura concinnata (Meig.): 150,000 liberated between 1906 and 1927; collection, less than two dozen specimens of those years, not indicated whether from colonies, releases, or recoveries.

Parasetigena silvestris (R.D.): Many thousands liberated; collection, five poor European specimens, unrelated to that project.

Exorista larvarum (L.): 50,000 liberated; collection, two specimens possibly representative of the releases.

A case history in point is that of some chalcid parasites of the gray sugarcane mealybug, *Pseudococcus boninsis* (Kuwana). In 1932 *Aphycus* (as *Pseudococcobius*) *terryi* (Fullaway) was introduced from Hawaii and propagated in a Louisiana laboratory. Between 1932 and 1936 releases were made in three States and Puerto Rico. It was reported as apparently established in Louisiana. Much later (1943) some material of so-called *terryi* was submitted to a taxonomist, who found that it was actually another genus and a new species, which he described as *Pseudaphycus mundus* Gahan. In backtracking on the problem, the taxonomist was able to secure specimens from the original shipment from Hawaii, and they were indeed true *terryi*. But of the numerous releases and recoveries, there was found material presumed to be of only one release and one recovery, neither of which was certainly labeled as such. Both the released and recovered specimens proved to be *mundus*, believed to be an endemic species somehow introduced into the propagation process. Lack of preserved samples makes it impossible to trace the whole story, and to tell now whether true *terryi* was

ever released at all, or whether both *terryi* and *mundus* were released, or only the native *mundus*.

5. *Association of reared parasites with their immature stages and the host remains.*—The importance and usefulness of these associations and their careful preservation have been mentioned by others from time to time, but need repetition and emphasis. Except where one deals with cultured individuals of known history, every rearing is a potentially significant item in our long struggle for mastery of Nature's secrets. Association of the host remains, shriveled or fragmentary though they appear, may enable specialists to identify the host to genus or even to species, or at some future time to recheck the host record. Immature stages of the parasites may enable taxonomists to build toward a truly natural classification of the group, as well as toward more reliable identifications. A recent example is a study of dipterous parasites of the genus *Wagneria*. Study of available puparia of five species revealed two startlingly different and obviously unrelated types of spiracular plates. We are still baffled in trying to classify other species for which puparia are not known. The accumulation of such material is a slow process, in which the biological-control worker can play a significant part.

Changing taxonomic concepts and increasing refinement of taxonomic discrimination further highlight the importance of having preserved material which can be restudied and reevaluated. A pertinent example is that pest of many common names, *Heliothis armigera* (Hbn.). Common (1953) found that *armigera* in Australia is a mixture of two species, the typical *armigera* and another species for which he found an old name, *punctigera* Wallengren. Furthermore, he said that the Western Hemisphere species was not *armigera* but still a different one, which is apparently the same from Manitoba to Argentina. True *armigera* occurs in the Old World from Europe to Australasia.

WHAT BIOLOGICAL-CONTROL WORKERS CAN DO FOR TAXONOMISTS.—Having discussed these general needs for closer cooperation, I should now like to consider what biological-control workers can do for taxonomists.

1. *Important information and material.*—Biological-control workers have furnished, and can furnish, taxonomists with a great deal of important information and material, including host-parasite lists, reared material, series for analysis of variation, associated immature stages, and distribution data. However, they are also building a store of other basic information that will aid taxonomists in acquiring a complete understanding and in revising the classifications of their groups. Life history, type of egg laid, mating behavior, place of pupation—all such matters are important in the bionomics of species. Often they are good taxonomic characters, even though conventional descriptions are usually morphological. The information is ordinarily secured by biological-control workers because it is a field proposition. Taxonomists should be encouraged and permitted to participate, though unfortunately lack of time and funds tends to exclude them.

2. *Techniques.*—With living material available, biological-control workers can try out such techniques as cytological analysis, precipitin tests, and cross-breeding. Taxonomists should follow those studies with interest, as contributing to the completeness of knowledge about species. They may not always be able to use the information in identifying the pinned or preserved carcasses with which they usually deal, but total knowledge of an insect, which should be our ultimate goal, is more than a description of the chassis or a list of the parts and accessories.

In "The New Systematics," edited by Julian Huxley (1940), Diver noted that the taxonomist must usually work from dead material, and remarked that "the fields of developmental, physiological, ecological, bionomic, cytogenetic, and biochemical variability are usually closed to him." Those are aspects in which biological-control workers can contribute much of value to taxonomists, and the latter should make use of them and as far as possible cooperate in such studies.

3. *The furnishing of clues to possible differences in populations* is a third general way in which biological-control workers can do much for taxomomists. Two species of spruce sawflies, *Diprion hercyniae* Hartig and *D. polytomum* Hartig, were once thought to be synonymous but are now distinguished by differences in chromosome numbers, tendency to diapause, and type of parthenogenesis. All three characters are not available in ordinary identification work, but they are certainly significant for the taxonomist in weighing the status of the two forms. Taxonomists' distinction between the palaearctic *Exorista larvarum* (L.) and our native *E. mella* (Walker) stems from observance by biological-control workers of differences in host and place of pupation, and in characters of the first-stage larvae. As another example, Boyes & Wilkes (1953), writing on the somatic chromosomes of Diptera, included those of *Aplomya caesar* (Ald.) from the European corn borer. A larva of *caesar* from the spruce budworm showed differences in the size and morphology of the X-chromosome. That larva represents, according to Boyes and Wilkes, "either extreme variation or a distinct subgroup of this species attacking the budworm." Those are challenging words for both taxonomists and biological-control workers. Whatever it is—a strain, a subspecies, or even a distinct species—we have there a clue, a fair warning.

Biological-control workers may also call attention to overlooked similarities. In 1925 Aldrich described a new parasite of *Popillia* from Korea as *Dexia ventralis*. In recent years *Dexilla vacua* (Fallén) has been imported from France as a parasite of *Amphimallon*. Adults of the two parasites have not been satisfactorily separated taxonomically in the available material. It was an observant biological-control worker at Moorestown, N. J., who called attention to the close resemblance of *ventralis* and *vacua* in actions and in habitus.

WHAT TAXONOMISTS CAN DO FOR BIOLOGICAL CONTROL WORKERS.—I should now like to discuss what taxonomists can do for biological-control workers.

1. *Basic identifications.*—It is axiomatic that the furnishing of basic identifications is a primary function of taxonomists in any biological-control project. Reduced to its simplest terms, every biological-control problem—and for that matter every control problem—begins with a pest. And the very first question, the *sine qua non*, is the simple "What is it?" The duty of taxonomy is to answer that question, as promptly, as completely, and as accurately as possible. Only then can the operations of

biological control effectively be planned and developed.

The answer may be easy and definite, or it may take long study, searching of literature, or consultation with taxonomists in other countries. In some cases the species is new to science, and the taxonomist proceeds to describe and christen it. If it is clearly new, the problem is easy. But if it is one of a group with many already described species scattered around the world, the conscientious seeker for truth is faced with many problems and the time-consuming and exacting seeking out and evaluating of scattered crumbs of information, some half-baked loaves, and here and there a few kernels of good grain. That is the labor and responsibility of taxonomists—to answer the question "What is it?"

Once the identity of the pest is known, then, assuming that we are not concerned with temporary measures, the second fundamental question is "Where is its native home?" That too is a proper question for taxonomy. It was significant in that famous example, the introduction of the vedalia beetle into California for control of the cottony-cushion scale. The basic identification of the scale and the knowledge that it occurred in Australia were key points in the entire project. Again, when a destructive beetle was found in New Jersey, its identification as *Popillia japonica* Newm. directed the search for its parasites to Japan and, by extension to other species of *Popillia*, to the Far East in general. Such guidance, by definite information or clues, is one of the most important functions of taxonomists in the field of biological control.

Again the question—"What is it?" For taxonomists not only had to answer the question initially for the pest, but they must now answer the same question for the parasites, and perhaps for a rogues' gallery of hyperparasites and inquilines and predators, sometimes again and again. I need only refer to the wide-ranging exploratory surveys, such as those for parasites of the oriental fruit fly, the Japanese beetle, and the citrus blackfly. Many are collected but few are chosen; nevertheless, all require identification.

So parasites are introduced, but taxonomy is not yet out of the picture. There will be surveys in areas where parasites were released. Once more biological-control workers may turn to taxonomists with that last, that most poignant of all their questions—that which touches the heart, the philosophy, and the budget—"Did we succeed?"

It is in attempting to answer this question that taxonomists so often have occasion to lament past failures to coordinate the two fields in some of the matters discussed earlier.

Before leaving the subject of identification, may I remind you that a name is valuable in itself. A. B. Gahan (1923) has succinctly stated it as follows: "Objects without names cannot well be talked about or written about; without descriptions they cannot be identified and such knowledge as may have accumulated regarding them is sealed; unclassified their relations are unknown and the possibilities of deduction are destroyed."

2. *The cataloguing and assimilation of knowledge about species* is accepted by modern taxonomists as their responsibility. The ultimate solution of a biological-control problem may be extremely complex when such factors as host-parasite relations and alternate hosts must be considered. On such matters the taxonomist's function "to discover, evaluate, digest, and organize knowledge concerning insects," as recently expressed by P. W. Oman, can be of great importance to the biological-control worker in the stockpiling of information about species.

3. *Fundamental information and interesting clues.*—Finally, taxonomists' research on classification, which might be considered of secondary interest to the biological-control worker, can nevertheless furnish some fundamental information and interesting clues. These can be of great practical importance in biological control.

An excellent example of the role of taxonomists' integrated information in biological-control projects is furnished by the beet leafhopper, *Circulifer tenellus* (Baker), and the search for its parasites. Early surveys in 1926 and 1927 were unsuccessful in finding the native home, entomologists having been led astray partly by mislabeled specimens of *Eutettix tenellus*, as it was then called, and partly by the existing knowledge of a curly-top disease in South America, since proved to be transmitted by entirely different leafhoppers, of the subfamily Agalliinae.

Oman (1936) called attention to the apparent synonymy of *Eutettix tenellus* and a species described from Israel. He also pointed out that *tenellus* is not a true *Eutettix*, a genus of large oak-feeding leafhoppers, but the generic position was left open pending further study. Oman (1948, also in memoranda 1940–42) finally concluded that *tenellus* belongs to a group of species of the genus *Circulifer* occurring in the arid and semi-arid regions around the Mediterranean and across central Asia. Therefore, when it was decided to renew the search for parasites of the beet leafhopper, taxonomists could point to the Mediterranean area. In 1951 Norman W. Frazier, of the University of California, spent 7 months collecting material of *Circulifer* on both sides of the Mediterranean from Spain to Turkey. Analysis of that material culminated in the significant report of Young & Frazier (1954) on "A Study of the Leafhopper Genus Circulifer." This work has confirmed not only that close relatives of the beet leafhopper occur throughout the Mediterranean region, but that the beet leafhopper itself occurs there. The search for its parasites has thus been concentrated in that part of the world.

Another example of taxonomists' organization of information is a dipterous parasite of the Japanese beetle. Discovered in Japan, it was named by J. M. Aldrich in 1923 as a new genus and new species, *Centeter cinerea*. Recently it was discovered that *Centeter* is not a distinct far-eastern genus, but rather a part of the old genus *Hyperecteina* Schiner, originally described from France and known from several species across southern Europe. Six species have now been reared from various scarabaeid adults, including *Amphimallon* in France. It thus appears now that the genus ranges widely from France to Japan, and is normally parasitic on Scarabaeidae.

This organization of information might be especially valuable in the future. If there are regions where exploration for parasites is no longer possible, it may be very important to know the range of a genus, and of species closely related to whatever pest concerns us. In the absence or ineffectiveness of parasites of a particular pest,

those attacking its relatives may be of considerable importance. For example, in Fiji control of the coconut moth, *Levuana iridescens* B.B., whose native home was unknown, was spectacularly successful when entomologists introduced from Malaya a dipterous parasite of an allied zygaenid moth, *Artona catoxantha* (Hampson). Of direct interest in this country, some enemies of the Japanese beetle, such as the important *Tiphia vernalis* Rohwer, were parasites of other species of *Popillia* but later proved to be successful against *japonica*.

Those are ways in which taxonomists can help biological-control workers. It must be admitted that taxonomists have not always helped on problems. Some of the fault inevitably lies in the partly avocational way taxonomy developed and has been supported, and in the intense individualism of many taxonomists. (One of the unsolved biological-control problems of history is how to control taxonomists!) In no field is it more true that the evil men do lives after them. But errors of the past should not blind us to the good that has been done, and the good that can be done, by cooperation and the maximum use of each field by workers in the other.

It is not always possible to blame anyone. Our present views are hindsight from vantage positions gained as a result of progress, such as the differentiation of red and yellow scales, and of mealybugs of the genus *Pseudococcus*, and the many other cases which represent the results of modern advances and refinements of knowledge. Entomological taxonomy is not different in that respect from other fields of endeavor, such as the recognition of numerous strains of wheat rust, and of various types of pneumonia. With more precise knowledge we have been able to resolve many problems that baffled or confused earlier investigators.

Biological-control workers are dealing with complex biological problems, with the interactions of populations of one to many parasites with one to many species of hosts, and with each other, and with hyperparasites, and all with populations of predators, and all in turn with climatic and other environmental factors. Likewise the taxonomy in biological-control problems can be a complex matter, involving the identification and classification of species of all those categories. All in all, the problems pose a real challenge to both taxonomists and biological-control workers, a challenge that can best be met by the fullest teamwork possible.

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Insecticides in Mineral Oil Emulsions for Control of the Corn Earworm and Fall Armyworm in Sweet Corn[1]

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During recent years a large number of insecticides have been tested by various workers for control of the corn earworm, *Heliothis armigera* (Hbn.), especially on corn, cotton, and tomatoes. The work on sweet corn was greatly accelerated after Barber (1938) showed that white mineral oil is toxic to the corn earworm when injected into the silk channels or sprayed on the tips of the ears. Barber (1941, 1944), Pepper & Barber (1940), Wilcox (1943), and Barber & Wilcox (1944) found that the addition of pyrethrum, dichloroethyl ether, or styrene dibromide increased the effectiveness of the mineral oil.

Control of the earworm on corn presents a special problem because the larvae, immediately upon hatching, move into the silk channels of the ears, where it is difficult to reach them with an insecticide. Dusts have been recommended where the infestation was light or moderate, but they have been unsatisfactory with heavy infestations unless large amounts were applied.

Pepper & Wilson (1947) reported good control with dusts containing TDE and DDT, and Kulash (1950) with dusts and sprays containing DDT, TDE, Prolan, toxaphene, and Bulan. Infestations in both cases were light to moderate. Butler & Carruth (1949) and Greenwood & Hoffmaster (1949) had variable results with impregnated DDT and parathion dusts against moderate infestations in New York and Virginia.

It is the opinion of a number of workers that a true comparison of sprays and dusts can be made only when 80 per cent or more of the untreated ears are infested.

[1] Accepted for publication April 27, 1955.

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[4] The authors express appreciation to J. M. Magner for aid in carrying out experiments in Illinois, and to D. J. McAlexander, farm manager for F. H. Vahlsing, Inc., Elsa, Tex., for supplying corn on which to conduct tests and for many other favors. They also thank the insecticide manufacturers and others who supplied materials for these tests. Many farmers kindly provided corn on which to conduct tests, as well as other facilities.

Table 1.—Conditions under which tests of insecticides for control of the corn earworm were carried out.

LOCATION	YEAR	CORN STRAIN	DATE OF APPLICATION	PER CENT EARS IN SILK	NUMBER OF EGGS PER SILK	NUMBER OF LARVAE PER EAR
Texas:						
Edinburg	1949	Ioana	May 3	55	3.6	0.6
			6	99	0.7	1.3
LaVilla	1950	Tri-State	April 14	46	4.4	0
	1951	Ioana	May 1	11	—	—
			4	79	5.5	1.7
			7	96	3.1	4.7
			2	44	9.0	0.8
			6	93	3.5	5.9
Mercedes	1951	Golden Security	May 14	8	4.7	0
			17	69	1.7	1.0
			20	94	1.5	1.5
	1952	Calumet	April 20	5	—	3.0
			23	—	5.0	3.8
			26	97	0.7	5.0
Illinois:						
Collinsville	1950	Ioana	Sept. 12	79	6.3	0.3
			14	94	1.9	—
	1951	Golden Security	Sept. 6	54	1.6	—
			10	98	0.8	1.8
Granite City	1950	Ioana	Sept. 14	32	3.5	0.2
			19	95	5.7	—
Edwardsville	1952	Golden Security	June 24	12	3.0	0.5
			27	76	1.4	0.6
			30	99	0.2	1.3
Alabama:						
Loxley	1951	Aristogold Bantam	June 8	16	2.9	0
			12	91	1.5	0.8
Indiana:						
Austin	1952	Southern Shipper	Aug. 13	72	1.9	0
			16	95	1.5	—
			19	99	1.1	3.4

Bacon (1950) states that "where large populations are involved, dusts have not proved effective. . . ." However, Anderson *et al.* (1951a) obtained good results in California under heavy infestations with several applications of DDT dust with a paint brush wherein the material was pushed deeply into the silk masses. Anderson *et al.* (1949, 1951b), Rutschky (1951), and Wene & Blanchard (1950) have shown that under most conditions dusts applied by the usual methods are inferior to sprays.

The most effective spray is a white mineral oil of 45 to 90 seconds Saybolt viscosity containing an insecticide. However, at the required dosages the oil prevents development of the tip kernels. Furthermore, it is too expensive for machine application with any method yet devised.

Emulsion sprays containing insecticides and oil give control approaching that obtained with insecticides in oil solution. With methods of application and materials used at present, such sprays must contain at least 5 per cent of oil to be effective where infestations are heavy. The oil helps the spray to penetrate the silk masses and to enter into the silk channels. Gouck & Blanchard (1951) have shown that emulsions containing 7.5 per cent of white mineral oil act as ovicides.

Various workers have conducted tests with insecticides both in oil solutions and in emulsions containing 5 to 10 per cent of oil. They have found DDT to be superior to the insecticides earlier recommended by Barber (1941). DDT is the most widely recommended insecticide for use in sprays (Anderson *et al.* 1949, Bacon 1950, Blanchard & Chamberlin 1948, Blanchard *et al.* 1951, Chamberlain 1951, Ditman 1950, Eden 1951, Rutschky 1951, Wene & Blanchard 1949). Certain other organic insecticides have been mentioned as having promise.

During the period 1949 to 1952 experiments for comparison of insecticides in emulsions containing mineral oil for control of the corn earworm were conducted in the Lower Rio Grande Valley of Texas, central Illinois, Alabama, and Indiana. Twenty insecticides were tested. Data on control of the fall armyworm, *Laphygma frugiperda* (J. E. Smith), were obtained in two experiments in Illinois in 1950 in which five insecticides were compared.

Corn earworm infestation in the Texas plots varied from severe to very severe during the 4 years. In the Alabama and Indiana plots it was severe. In Illinois severe infestations occurred in 1950, 1951 and 1952, and in 1950 the fall armyworm was also abundant.

MATERIALS AND METHODS.—Only proprietary emulsiable concentrates were available in 1949, and of some of the insecticides in other years. However, insofar as possible the insecticides tested were technical-grade materials to which known solvents and emulsifiers had been added. Where proprietary concentrates as well as technical insecticides were available, emulsions containing the same strength of insecticide were made from both for comparison.

Ten per cent of white mineral oil was added to the emulsions in 1949, and 7.5 per cent in 1950, 1951, and 1952. Three white mineral oils—of 45 to 50, 65 to 70, and 80 to 90 seconds Saybolt viscosity—were used, but the same oil was employed throughout each experiment.

Single-row plots 40 to 50 feet long were used. They were replicated three times in the five experiments conducted in 1949 and 1950, as well as in the one in Illinois in 1951. The plots were replicated four times in the other experiments.

All materials were applied with a 3-gallon compression sprayer. Only two applications were made in 1949 and 1950 and in all but two experiments in Texas in 1951. In one of the 1951 experiments in Texas all plots received

Table 2.—Effectiveness of insecticides in mineral oil emulsions against the corn earworm in sweet corn.[a]

INSECTICIDE (FIGURES IN PER CENT)	PER CENT OF WORM-FREE EARS	INSECTICIDE (FIGURES IN PER CENT)	PER CENT OF WORM-FREE EARS
DDT		Dieldrin	
0.5	92	0.5	58
1.0	93	1.0	83
TDE		Toxaphene	
0.5	85	1.0	57
1.0	87	Rotenone	
		0.07	68
Methoxychlor		Pyrethrum	
0.5	47	0.8	13
1.0	73	1.6	53
Aldrin		Untreated check	0
0.5	32	LSD—5%	24
1.0	65	1%	33

[a] Two applications. Edinburg, Texas, 1949.

Table 3.—Per cent of wormfree ears harvested from fields of sweet corn treated with insecticides in mineral oil emulsions to control corn earworm. Two applications, 1950.

Insecticide (Figures in Per Cent)	Solvent (Figures in Per Cent)	Collinsville, Ill.	Granite City, Ill.	Edinburg, Tex.	LaVilla, Tex.
DDT 0.25	Ethylene dichloride 1.0+ carbon tetrachloride 0.3	—	—	—	55
	Ethylene dichloride 1.0	—	—	62	75
DDT 0.5	Ethylene dichloride 0.75	—	—	72	71
	Propylene dichloride 0.75	—	—	77	—
	Propylene dichloride 1.0	55	72	—	89
DDT 0.75	Xylene 2.0	—	—	67	69
TDE 0.75	Propylene dichloride 1.0	—	68	—	—
TDE 1.0	Xylene 2.0	45	52	61	91
	Propylene dichloride 1.0	49	—	—	—
Lindane 0.75	[a]	—	22	—	—
Lindane 0.5	[a]	18	13	—	—
	Propylene dichloride 1.0	12	22	—	—
Fluorine analog of DDT 0.75	[a]	—	23	—	—
Fluorine analog of DDT 0.5	[a]	24	—	—	—
Aldrin 0.75	[a]	—	—	65	—
	Xylene 2.0	—	—	—	73
Toxaphene 1.0	Xylene 2.0	—	—	—	48
Methoxychlor 1.0	Xylene 2.0	—	—	—	60
Heptachlor 0.75	[a]	—	—	70	—
Heptachlor 1.0	[a]	—	—	—	84
Dilan 0.75	[a]	—	—	—	47
	Ethylene dichloride 1.0	—	—	—	56
DDT 0.25+TEPP 0.2	[a]	—	—	42	—
Allethrin+hydroquinone 0.2 each	Propylene dichloride 1.0	0	2	—	—
Allethrin+propylisome+hydroquinone 0.2 each	Xylene 0.4	5	5	—	—
	Propylene dichloride 1.0	6	—	—	—
	Propylene dichloride 0.4	—	5	—	—
Untreated check		7	7	0	2
L.S.D. at 5% level		15	17	19	15
L.S.D. at 1% level		20	24	—	19

[a] Proprietary emulsion.

three applications; in the other there were duplicate plots, one of which received two and the other three applications. Three applications were made in the 1952 experiments.

The first application was not made early enough in eight of the experiments, since for best results not more than 25 per cent of the ears should have been in silk.

In Texas, Alabama, and Indiana 1.5 to 2 ml. of spray was applied to individual ears at 40 to 50 pounds pressure from a nozzle that put out a hollow-cone stream. The amounts applied were based on practice spraying into a graduate.

Table 4.—Per cent of wormfree ears harvested from fields of sweet corn treated with insecticides in mineral oil emulsions to control the corn earworm. Two applications, 1951.

Insecticide (Figures in Per Cent)	Solvent (Figures in Per Cent)	LaVilla, Tex.	Loxley, Ala.	Collinsville, Ill.
DDT 0.05	Xylene 1.0	68	—	72
DDT 0.75	Xylene 2.0	—	78	—
	Xylene 1.5	—	—	82
DDT 0.5	Propylene dichloride 1.0	52	90	—
TDE 0.5	Xylene 1.0	18	—	—
	Propylene dichloride 1.5	38	—	—
TDE 0.75	Xylene 1.75	—	81	70
Dilan 0.5	Xylene 1.0	27	—	—
	Propylene dichloride 1.0	30	—	—
	[a]	57	—	—
Dilan 0.75	Xylene 1.5	—	—	48
	Xylene 2.0	—	76	—
	[a]	—	62	—
Prolan 0.5	Propylene dichloride 1.0	13	—	—
Prolan 0.75	Xylene 2.0	—	85	—
	Xylene 1.5	—	—	63
Bulan 0.5	Propylene dichloride 1.0	58	—	—
	Xylene 2.0	—	68	—
Bulan 0.75	Xylene 1.5	—	—	48
Heptachlor 0.5	[a]	48	—	—
Heptachlor 0.75	[a]	—	85	—
Endrin 0.03	[a]	—	33	2
Isodrin 0.03	[a]	—	—	5
Untreated check		0	22	0
L.S.D. at 5% level		17	17	14
L.S.D. at 1% level		22	23	18

[a] Proprietary.

Table 5.—Per cent of wormfree ears harvested from fields of sweet corn treated with insecticides in mineral oil emulsions to control the corn earworm. Three applications, 1951.

Insecticide (Figures in Per Cent)	Solvent (Figures in Per Cent)	LaVilla, Tex.	Mercedes, Tex.
DDT 0.33	Propylene dichloride 1.0	67	—
DDT 0.5	Propylene dichloride 1.0	70	90
DDT 0.75	Xylene 2.0	—	78
TDE 0.5	Xylene 1.0	46	—
	Propylene dichloride 1.0	47	—
Dilan 0.5	Propylene dichloride 1.0	65	—
Prolan 0.5	Propylene dichloride 1.0	72	—
Bulan 0.5	Propylene dichloride 1.0	58	—
Endrin 0.03	[a]	—	91
Toxaphene 0.75	Benzene 1.0	—	85
	Toluene 1.0	—	57
	Xylene 1.0	—	77
	Kerosene 1.0	—	62
Toxaphene 1.5	Benzene 2.0	—	78
	Toluene 2.0	—	87
	Xylene 2.0	—	78
	Kerosene 2.0	—	85
Perthane 0.5	[a]	46	—
Untreated check		0	0
L.S.D. at 5% level		17	15
L.S.D. at 1% level		23	—[b]

[a] Proprietary.
[b] Not significant.

Table 6.—Per cent of wormfree ears harvested from fields of sweet corn treated with insecticides in mineral oil emulsions to control the corn earworm. Three applications, 1952.

INSECTICIDE (FIGURES IN PER CENT)	SOLVENT (FIGURES IN PER CENT)	MERCEDES, TEX.	EDWARDSVILLE, ILL.	AUSTIN, IND.
DDT 0.5	Xylene 1.0	88	95	87
DDT 0.75	Xylene 2.0	75	93	98
DDT 0.5	Propylene dichloride 1.0	85	96	—
	Propylene dichloride 2.0	96	96	—
Methoxychlor 0.75	[a]	21	—	—
Methoxychlor 1.5	[a]	26	—	—
Heptachlor 0.75	Xylene 2.0	48	—	—
	[a]	78	78	88
Heptachlor 1.0	[a]	—	68	—
TDE 0.75	Xylene 2.0	68	—	—
Dilan 0.75	Xylene 1.5	—	85	—
	Xylene 2.0	40	—	—
Dilan 1.0	Xylene 2.0	—	75	—
Prolan 0.75	Xylene 2.0	57	—	—
Bulan 0.75	Xylene 2.0	40	—	—
Aldrin 0.75	Xylene 1.5	27	—	—
	[a]	36	—	—
Dieldrin 0.75	Xylene 1.5	78	—	—
	[a]	62	—	—
Endrin 0.03	Xylene 0.06	12	—	—
Endrin 0.06	Xylene 0.12	45	—	—
	[a]	—	83	—
Endrin 0.10	[a]	—	70	78
	Xylene 0.20	—	66	80
Endrin 0.20	[a]	—	95	—
	Xylene 0.40	—	—	91
	[a]	—	95	82
Isodrin 0.03	Xylene 0.06	15	—	—
Isodrin 0.06	Xylene 0.12	20	—	—
Untreated check		0	13	0
L.S.D. at 5% level		9	17	8
L.S.D. at 1% level		12	22	11

[a] Proprietary.

In Illinois a single nozzle was used in 1950 and 1952, and a boom having two drops each with a single nozzle in 1951. All the nozzles gave a flat fan spray, and the spray was applied at 60 to 70 pounds' pressure. With the single nozzle the operator walked along the row first on one side and then the other, directing the spray at the ears at the rate of approximately 35 gallons per acre. When he used the boom, he held it over the tops of the plants to spray the ears from each side, applying about 25 gallons per acre.

The percentage of ears in silk was determined from 5 counts of 100 plants made at different locations in the plots. The number of eggs per silk was obtained by examining two fresh silk masses in five locations in each plot. Ten of the older ears in most of the plots were examined to determine the number of larvae entering the ears at the time the sprays were applied. The percentages of wormfree ears were based on the examination of 15 ears in each replication.

To compare control, the various insecticides were assigned values from 1 to 4 in each test. Treatments receiving a value of 1 included the best one and those not significantly different from it at the 5 per cent level. A treatment was assigned a value of 2 if it differed significantly from the best and a value of 3 or 4, if it differed significantly from the treatment given the next higher value.

RESULTS.—Table 1 gives data on the strains of corn in the tests, dates of the spray application, rates of silking, and abundance of the earworm. The effectiveness of the different insecticides is shown in tables 2 to 6. A summary of the insecticides, the number of times they were tested, and their relative ranks is given in table 7.

Table 7.—Relative effectiveness of insecticides tested for control of the corn earworm in sweet corn, 1949–1952.

INSECTICIDE	NUMBER OF TESTS	AVERAGE RANK
DDT	32	1.19
Endrin	3	1.33
Toxaphene	10	1.50
TDE	15	1.60
Heptachlor	8	1.87
Rotenone	1	2.00
Perthane	1	2.00
DDT and TEPP	1	2.00
Bulan	5	2.20
Dilan	11	2.27
Prolan	5	2.40
Dieldrin	4	2.50
Methoxychlor	5	2.80
Aldrin	4	3.00
Fluorine analog of DDT	2	3.00
Ethylene dichloride	1	3.00
Pyrethrum	2	3.00
Lindane	6	3.17
Allethrin	6	4.00
Isodrin	6	4.00

SUMMARY.—From 1949 to 1952 experiments were conducted in various States with insecticides in mineral oil emulsions for control of the corn earworm, *Heliothis armigera* (Hbn.). In some of these experiments data were also obtained on the control of the fall armyworm, *Laphygma frugiperda* (J. E. Smith).

DDT and endrin gave the best control of the corn earworm. Toxaphene, TDE, and heptachlor were almost as effective. Dilan, Prolan, Bulan, dieldrin, and methoxychlor also showed possibilities. Rotenone and Perthane had only one test each, and their rating cannot be considered final. Aldrin, the fluorine analog of DDT, pyrethrum, lindane, allethrin, and isodrin were unsatisfactory. Ethylene dichloride was highly toxic, but its high volatility made it unsatisfactory when sprayed in an oil emulsion. A mixture containing 0.25 per cent of DDT and 0.2 per cent of TEPP was no better than 0.25 per cent of DDT. Toxaphene caused moderate to severe burning of the corn when used at strengths necessary to give good control. None of the other insecticides injured the plants.

In Illinois DDT, lindane, and TDE all gave complete control of the fall armyworm in one test and highly satisfactory control in another. The fluorine analog of DDT and allethrin reduced the population of the insect 85 and 62 per cent, respectively. None of the other insecticides were tested against it.

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Control of Common Alfalfa Insects in Wisconsin[1]

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In recent years a relatively large number of new organic polychlor and phosphate insecticides have been developed. Many have been evaluated in the research reported in this paper, with the objective of finding the insecticides most suitable for control of the insects most commonly infesting alfalfa in Wisconsin. After the data on effectiveness were available, it was possible to consider the practical limitations and/or hazards of the various insecticides in the seed or feed crops, and make recommendations accordingly.

ECOLOGY.—Two crops of alfalfa are normally produced per year in Wisconsin. Usually the first crop is grown under favorable conditions, and is largely harvested before insects become abundant enough to reduce yields seriously. An exception occurs in the east-central area adjacent to Lake Michigan where large numbers of the meadow spittlebug, *Philaenus leucophthalmus* (L.), may cause losses up to 20 per cent, according to Medler *et al.* (1953). Chlorinated hydrocarbons as a group were reported by Medler (1954) to be effective insecticides for meadow spittlebug control in first crop alfalfa, but phosphates, nitroparaffins, and insecticides of plant origin were not effective.

The tarnished plant bug, *Lygus lineolaris* (P. de B.), and the alfalfa plant bug, *Adelphocoris lineolatus* (Goeze), are species of mirids commonly found in the first growth. Nymphs of the alfalfa plant bug appear when overwintering eggs in alfalfa hatch. In contrast, nymphs of the tarnished plant bug hatch from eggs which are laid by adults migrating into alfalfa during the spring. For both species, the dates of first appearance and the abundance of the nymphs vary widely between fields and between seasons. The two species are known to be very injurious to first crop seed production. The extent of their damage to first crop forage production has not been completely evaluated, although serious injury has been observed under circumstances of heavy attack and unfavorable conditions for plant growth.

The second crop of alfalfa is often grown under the stress of several unfavorable environmental factors, one of which is insect attack. The adult insects continually migrate into the young growth. They not only cause injury by their feeding, but are a source of eggs which hatch into large numbers of nymphs. In addition to the two species of mirid bugs already named the potato leafhopper, *Empoasca fabae* (Harris), is a common species. The abundance of the three species in the second growth is influenced by seasonal weather conditions, attractiveness of fields to migrants and the overlapping of insect generations. In some years grasshoppers also are numerous. The removal of the first crop apparently hastens the warming of the soil and results in a hatch of grasshopper eggs in the second growth. The development of grasshoppers is such that the adults become a particularly serious problem if the alfalfa is saved for second crop seed. The species are predominantly *Melanoplus mexicanus mexicanus* (Sauss.) and *M. femur-rubrum* (Deg.).

Although the same insects are involved whether the second crop of alfalfa is harvested for forage or for seed, the utilization of insecticides for insect control in the separate growths is governed by entirely different principles. Seed production requires that insecticidal controls be long-lasting and highly effective for all major species. This requirement of preventive control is best fulfilled at present by the use of residual chlorinated hydrocarbons. Medler & Scholl (1947) showed that insecticides contain-

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ing DDT were effective for controlling insects in seed fields. Medler & Chamberlin (1949) reported that low volume sprayers could be utilized for the control of alfalfa insects, and indicated that emulsions were more desirable for use in sprayers with limited capacity. They stated that the method of application appeared secondary to the dosage of toxicant per acre. Medler & Chamberlin (1950) showed that low volume applications of aldrin, chlordane and toxaphene were effective for grasshopper control, and that DDT in mixtures with toxaphene, aldrin and chlordane at half dosages gave better control of grasshoppers than DDT alone at full dosages.

Forage production, on the other hand, requires that the insecticides be acceptable for use on a feed crop. Since acceptable insecticides are largely phosphates and nonresidual chlorinated hydrocarbons, they may need application at high dosages (hence are costly) or they may rapidly lose their effectiveness. For maximum effectiveness, such insecticides must be applied at times when a species is at the incipient peak of its injurious population. The peaks of the major species in the second growth may not occur at the same time; therefore, an insecticide application for one species may not be timed correctly for the other species. In those instances only a partial control of the injurious populations can be obtained with one application. Medler & Fisher (1953) used methoxychlor and parathion for insect control in second growth alfalfa since these insecticides apparently have a limited hazard on feeds. They reported increases in the yield and quality of the second crop hay as a result of the treatments.

METHODS.—Since plot design can influence the precision and effectiveness of experiments, it seems desirable to discuss the suitability of the methods used for insecticide research on alfalfa insects. The randomized block design is usually considered to be the simplest method of plot design that gives a valid estimate of error. The Latin square is a more precise design in that it gives error control in two directions, but has not been considered practical in the field tests of insecticides on alfalfa because the restrictions of the design make it difficult to apply treatments with power equipment.

In our early research, two procedures were used in the randomized block design in order to overcome variation. The first was to increase the size of plots, the second was to increase the replication. The latter was preferred because the standard error of the mean of one treatment was decreased in proportion to the square root of the number of replications, and a better estimate of error was obtained.

The large plots (up to 5 acres) were located in farmers' fields. Medler & Scholl (1947) made applications uniformly in 6 different alfalfa fields each with 4 treatments replicated 3 times. An analysis of variance of the data from each field showed significant differences in treatments only in one field. Since the same treatments had been applied in all fields, a further statistical analysis could be made in which each field was considered as a randomized block of one experiment. This analysis showed significant differences between treatment and check. Additional experience with alfalfa insects has shown that large plots are best for the practical demonstration of an insecticide's effectiveness after the preliminary evaluation has been made.

It is not practical to test a long series of insecticides with a large plot design. When the testing of many new insecticides was started in 1950, the plots were reduced to 30′×145.2′ (1/10 acre) with a realization that the small size of the plot was subject to certain limitations. It was known that soil topography influenced the stand and vigor of alfalfa, and that this complex in turn influenced the abundance and distribution of the insects. For example, in one field it was found that nymphs of the alfalfa plant bug averaged 6.5 per sweep at one station and 55 per sweep at another station about 100 feet away. The only apparent difference in the field was a slightly higher elevation of ground at the station having the smaller number of insects per sweep, but there seemed little doubt that the deposition of eggs was influenced by a plant factor. "Border effect" is another special problem of small plots. Alfalfa insects are quite active. The elimination of migrants that takes place in a plot treated with a residual insecticide may result in reduced numbers in adjacent plots. This may obscure the differences between treatments or between treated and untreated areas, especially when plots are too narrow. On the other hand, control of error due to variation in soil topography and plants is best obtained by using long, narrow plots replicated at least four times.

The simultaneous testing of a large number of insecticides in replicated field plots was considered impractical. Also, the seasonal variations of the major species of alfalfa insects might result in an inadequate test of one or more species. It was hoped that the repetition of the tests for a period of several years would overcome these problems and provide data needed for a satisfactory analysis. The variations within and between plots were compensated for to a certain degree by including untreated check plots at random among the unreplicated insecticide treatments.

All of the second crop fields used in the tests were of alfalfa of uniform stand located on the University Farm at Madison. The first crop fields were at the Sheboygan County Farm. Samples of insects were obtained by sweeping with a 15-inch insect net. The per cent insect control was computed on the basis of the reduction of insects in treated plots in relation to untreated check plots. The checks lying on either side of a treatment were averaged and the average was used in calculating the per cent reductions. The per cent reductions were not calculated unless the checks showed 10 or more insects per 100 sweeps.

All insecticides were emulsion sprays applied at 40 lbs. pressure and at 10 gallons per acre with a 5 h.p. garden tractor equipped with a compressor, pressure tank and a 14-foot boom. The insecticides were formulated in the laboratory when possible, the emulsifiable solutions being uniform with respect to xylene solvent and emulsifier (2 parts Triton X-155 and 3 parts Triton B-1956). This procedure reduced the complications which could be caused by the various unknowns and year to year changes in commercial formulations. However, commercial formulations had to be used in some cases, particularly as new phosphates were included. These are indicated in the tables by footnotes.

RESULTS.—The reductions of insects in the treated plots in relation to untreated checks are shown in tables 1 and 2. The percentages are rounded to the nearest whole

Table 1.—Per cent reductions from untreated checks of alfalfa insects in 4-year test of insecticides in Wisconsin.[a]

Insecticide and Pounds Technical per Acre		1950[b] 1st Crop N	1950[b] 2nd Crop A	1950[b] 2nd Crop N	1951[c] 2nd Crop A	1951[c] 2nd Crop N	1952[d] 1st Crop A	1952[d] 1st Crop N	1952[d] 2nd Crop A	1952[d] 2nd Crop N	1954[e] 2nd Crop A	1954[e] 2nd Crop N	Average[f] A	Average[f] N
Alfalfa Plant Bug														
Aldrin	0.25	100	100	100	*	100	0	0	nt	nt		*	*50*	*75*
Chlordane	1	100	100	100	*	*	nt	nt	nt	nt		nt	(100)	100
CS-728[g]	1	nt	nt	nt	*	*	63	88	0	0		79	*32*	*56*
DDT	.5	100	100	100	*	*	77	75	nt	nt		100	89	94
	1	100	100	100	0	*	83	100	5	100		100	*47*	100
DDT+ dieldrin	.5 .125	nt	100	100	*	*	nt	nt	55	100		*	78	100
Dieldrin	.25	100	100	100	*	100	52	94	73	100		100	75	99
Dilan	1	nt	nt	nt	*	*	36	87	0	62		nt	*18*	*75*
Heptachlor	.25	100	89	93	*	*	33	88	nt	nt		*	61	94
Lindane	.25	100	*	100	*	*	28	44	0	69		nt	*14*	*78*
Methoxychlor[h]	1	0	nt	nt	nt	nt	43	56	18	54		97	*31*	*52*
	2	0	81	98	57	93	70	48	16	55		nt	*56*	*59*
Parathion[h]	.16	100	100	100	*	*	87	32	nt	nt		nt	94	*77*
	.33	100	100	100	*	*	39	85	61	100		100	67	97
Perthane	.5	0	*	100	*	*	0	33	nt	nt		nt	(0)	*44*
	1	0	50	100	*	*	0	72	16	24		76	*27*	*54*
Systox[h]	.25	nt	nt	nt	nt	nt	78	66	0	77		100	*39*	*81*
Toxaphene	.5	100	*	100	*	*	89	97	nt	nt		100	(89)	99
	.75	nt	nt	nt	*	*	82	90	nt	nt		100	(82)	95
	1	100	*	100	*	*	82	74	nt	nt		100	(82)	94
Mean Check[i]		279	41	133	7	2	58	38	60	42		40	56	81
Tarnished Plant Bug														
Aldrin	.25	100	80	100	5	100	39	0	nt	nt	25	*	37	75
Chlordane	1	89	80	*	30	100	nt	nt	nt	nt	nt	nt	55	95
CS-728	1	nt	nt	nt	0	0	64	36	0	0	0	43	*16*	*20*
DDT	.5	100	50	*	0	100	95	88	nt	nt	0	*	36	96
	1	100	74	100	0	100	90	100	0	98	18	100	36	99
DDT +dieldrin	.5 .125	nt	94	100	0	100	nt	nt	0	98	59	100	38	99
Dieldrin	.25	100	94	100	30	96	78	97	17	99	41	*	52	98
Dilan[b]	1	nt	nt	nt	12	0	0	0	0	54	nt	nt	*4*	*18*
Heptachlor	.25	100	55	*	42	100	66	54	nt	nt	38	*	50	85
Lindane	.25	100	38	*	30	95	75	40	0	85	nt	nt	36	80
Methoxychlor[h]	1	94	nt	nt	nt	nt	0	7	0	66	0	89	*0*	*64*
	2	94	0	0	0	0	14	21	0	24	nt	nt	*4*	*28*
Parathion[h]	.16	100	13	*	0	69	80	0	nt	nt	nt	nt	31	*56*
	.33	100	42	*	13	66	80	50	0	98	0	*	*27*	79
Perthane	.5	83	0	*	0	0	0	56	nt	nt	nt	nt	*0*	*46*
	1	0	36	*	0	0	0	36	0	29	15	71	*10*	*27*
Systox[h]	.25	nt	nt	nt	nt	nt	80	64	0	71	6	*	68	*29*
Toxaphene	.5	94	80	*	0	100	89	87	nt	nt	0	97	*30*	95
	.75	nt	nt	nt	0	100	96	86	nt	nt	0	100	32	95
	1	100	60	*	0	100	88	93	nt	nt	11	100	40	98
Mean Check[i]		178	81	27	142	86	120	246	215	417	55	82	30	69
Potato Leafhopper														
Aldrin	.25		17	38	34	*			nt	nt	0	55	*17*	*47*
Chlordane	1		1	*	0	*			nt	nt	nt	nt	*1*	—
CS-728	1		nt	nt	30	*			63	83	67	100	*53*	92
DDT	.5		52	*	67	*			nt	nt	80	100	66	(100)
	1		99	100	91	100			92	100	86	92	92	98
DDT +dieldrin	.5 .125		95	100	71	*			91	100	80	100	84	100
Dieldrin	.25		69	95	8	*			24	63	12	*	*28*	*79*
Dilan	1		nt	nt	41	*			97	100	nt	nt	76	(100)
Heptachlor	.25		0	*	20	*			nt	nt	0	29	*7*	(29)
Lindane	.25		0	75	0	*			66	70	nt	nt	*22*	*73*
Methoxychlor[h]	1		nt	nt	nt	nt			93	100	96	100	95	100
	2		77	*	96	100			97	100	nt	nt	90	100
Parathion[h]	.16		38	100	27	*			nt	nt	nt	nt	*33*	(100)
	.33		61	38	47	*			80	94	71	100	65	*77*
Perthane	.5		90	*	60	*			nt	nt	nt	nt	75	—
	1		80	100	72	*			92	100	89	100	83	100
Systox[h]	.25		nt	nt	nt	nt			97	100	76	100	87	100
Toxaphene	.5		5	*	20	*			nt	nt	11	77	*12*	*(77)*
	.75		nt	nt	64	*			nt	nt	39	87	*52*	*(87)*
	1		46	*	54	*			nt	nt	66	100	55	(100)
Mean Check[i]			385	107	127	8			1297	482	471	26	54	87

[a] A, adult; N, nymph; *, not computed because check had less than 10 insects/100 sweeps; nt, not tested.

[b] 1950—1st growth treated June 6, sampled June 22 (16 days); 2nd growth: combined data from 2 tests: (1), treated July 13, sampled July 24 (11 days), and (2), treated Aug. 16, sampled Aug. 25 (9 days); 8 check plots included in first growth; 20 check plots included in second growth.

[c] 1951—Combined data from 2 tests: (1), treated July 23, sampled July 30 (8 days), and (2), treated Aug. 16, sampled Aug. 24 (8 days); 8 check plots included.

[d] 1952—1st growth treated May 16, sampled June 19 (34 days); 2nd growth treated July 24, sampled Aug. 7 (14 days); 18 check plots included in first growth; 2 check plots included in 2nd growth.

[e] 1954—Plots treated July 19, sampled July 26 (7 days); 14 check plots included.

[f] Italicized numbers are below the mean; ( ) not an average.

[g] 2-nitro-1-phenyl-1-p-chlorophenyl butane (Commercial Solvent Corp.).

[h] Commercial formulation used.

[i] Average per 100 sweeps.

Table 2.—Per cent reductions from untreated checks of grasshopper nymphs in 4-year test of insecticides.†

Insecticide and Pounds Technical per Acre		1950[b] 2nd Crop N	1951[c] 2nd Crop N	1952[d] 2nd Crop N	1954[e] 2nd Crop N	Average[f]	All Insects—Rating of Insecticides on Basis of Frequencies Above Means[j] A	N	Both
Aldrin	0.25	89	*	nt	97	93	1	2	3
Chlordane	1	100	*	nt	nt	(100)	2	3	(5)
CS-728[g]	1	nt	*	89	96	93	—	2	2
DDT	.5	33	64	nt	0	*32*	3	3	(6)
	1	92	38	0	30	*40*	2	3	5
DDT +dieldrin	0.5 0.125	100	93	98	98	97	3	4	7
Dieldrin	.25	100	*	99	100	99	2	3	5
Dilan	1	nt	*	69	nt	(69)	1	1	(2)
Heptachlor	.25	62	*	nt	99	81	2	3	5
Lindane	.25	71	*	70	nt	*71*	1	1	2
Methoxychlor[h]	1	nt	nt	69	93	81	1	2	3
	2	14	40	9	nt	*21*	1	1	2
Parathion[h]	1/6	91	*	nt	nt	(91)	2	2	(4)
	1/3	93	*	54	99	82	2	3	5
Perthane	.5	*	57	nt	nt	(57)	1	—	1
	1	0	15	0	76	*23*	1	1	2
Systox[h]	.25	nt	nt	59	99	79	2	2	4
Toxaphene	.5	100	100	nt	93	98	1	3	(4)
	.75	nt	100	nt	97	99	2	3	(5)
	1	100	100	nt	99	99	3	4	(7)
Mean						75			
Check[i]		71	17	473	396				

† See table 1 for explanations of footnotes b–i, inclusive.
[j] Includes data in table 1. Maximum rating is 3 for A, 4 for N, 7 for both. ( ) is provisional.

number. The footnotes of table 1 give information on dates of tests, number of days between applications and counts of insects, and the number of check plots used. A number of insecticides or mixtures of insecticides were tested only once, and these are listed in table 3.

The control data are characterized by rather wide variations among the different insecticides, the four different species, the adult and nymphal stages of a species, and the years. Differences between insecticides, species and stages of a species were expected. The wide variations between the years seem to be unavoidable, since they were caused by the different populations of a species in plots at the time of a test. The magnitude of the differences is shown by the averages of insects per 100 sweeps in untreated checks, which ranged between 2 and 279 for the alfalfa plant bug, 27 and 417 for the tarnished plant bug, 8 and 1297 for the potato leafhopper and 17 and 473 for grasshoppers. Both adults and nymphs of the alfalfa plant bug, nymphs of the potato leafhopper, and nymphs of grasshoppers were unusually scarce in 1951.

Two factors resulted in 38% of the total possible data in tables 1 and 2 to be lacking. Either the per cent reductions were not computed if the untreated adjacent checks had less than 10 insects per 100 sweeps (13%), or insecticides were added or dropped during the 4-year period of the tests (25%).

The incompleteness of the data for the 20 formulations listed in tables 1 and 2 made it impractical to analyze the results by conventional statistical methods. An alternative method was adopted which allowed the insecticides to be rated on the basis of frequency above the mean of the average control obtained. The average control shown by each insecticide for each insect stage was summed and the mean determined, as shown in tables 1 and 2. Seven means were computed; one for adults and nymphs for each of three insects and one for grasshopper nymphs. A measure of an insecticide's effectiveness is therefore indicated by the number of frequencies above the mean, the best rating being seven. Because of the missing entries, the ratings are provisional for many of the insecticides and especially where the ratings are in parentheses. However, considerable information is available from the tests so that general conclusions can be made regarding the effectiveness of various insecticides, and it does not seem necessary to continue the experiment in order to obtain additional information.

The seven means were between 54 and 87 per cent except that the mean control of tarnished plant bug adults was only 30%. For each species, the mean control of the nymphs was better than the mean control of the adults. It is well known that mirid adults are active migrants, and the possibility has been mentioned earlier that a small plot design may be subject to error because of migrations. However, this error is not believed to have been a serious factor in these experiments, because 90% of the adult-numph pairs were either above or below the mean control. Inconsistent control above or below the mean for adult and nymph was shown especially by parathion, which was reversed for adult and nymph in 5 of 6 cases. This was probably due to the short residual effectiveness of parathion, and insect counts at 1 or 3 days after application would be expected to show more uniformity.

In order to show the relationships between insecticide

Table 3.—Control of alfalfa insects in one-year tests, supplementary to table 1.

Insecticide and Pounds Technical per Acre	Alfalfa Plant Bug		Tarnished Plant Bug		Potato Leafhopper		Grasshopper
	A	N	A	N	A	N	N
1950 only							
Bulan,[a] 1	*	100	71	*	90	*	*
Schradan,[a] 1	53	100	13	*	0	0	65
Prolan,[a] 1	100	100	20	*	74	100	100
BHC,[a] 0.25	*	100	0	*	0	0	43
CPR,[a,b] 0.1	50	91	14	0	54	0	9
CPR,[a] 0.2	*	0	0	*	0	*	0
Checks,[c] 20	41	133	81	27	385	107	71
1951 only							
DDT, 0.5+toxaphene, 0.75	*	*	0	100	75	*	100
DDT, 0.5+chlordane, 0.5	*	*	0	100	83	*	100
DDT, 0.5+aldrin, 0.125	*	*	4	100	73	*	93
DDT, 0.5+heptachlor, 0.125	*	*	22	100	68	*	93
Toxaphene, 1.5	*	*	0	100	51	*	100
Parathion,[a] 0.5	0	*	0	100	19	*	67
Checks,[c] 8	7	2	142	86	127	8	17
1954 only							
Dieldrin, 0.125	*	100	24	*	34	*	100
Endrin,[a] 0.1	*	96	10	*	40	62	100
Endrin,[a] 0.2	*	96	0	*	17	100	97
Isodrin,[a] 0.2	*	100	0	*	0	100	99
Isodrin,[a] 0.4	*	100	7	*	30	80	98
Parathion,[a] 0.125+aldrin, 0.125	*	100	27	*	62	100	100
Parathion,[a] 0.125+heptachlor, 0.125	*	100	7	*	61	100	95
Diazinon,[a] 0.5	*	100	0	98	54	100	89
Diazinon,[a] 1	*	95	0	100	46	100	95
Am. Cyanamid 4124,[a] 0.5	*	95	24	100	0	20	55
Am. Cyanamid 4124,[a] 1	*	100	0	100	0	35	62
Chlorthion,[a] 0.5	*	*	9	*	19	*	89
Chlorthion,[a] 1	*	*	30	*	0	*	89
Chlorthion,[a] 0.5+aldrin, 0.125	*	*	19	*	0	*	97
Chlorthion,[a] 0.5+heptachlor, 0.125	*	*	0	*	0	*	89
Malathion,[a] 0.625	*	*	0	100	3	*	89
Malathion,[a] 0.625+aldrin, 0.125	*	*	58	100	31	*	97
Malathion,[a] 0.625+heptachlor, 0.125	*	*	60	100	23	*	99
Checks,[c] 14	2	40	55	82	471	26	396

[a] Commercial formulation used.
[b] Piperonyl cyclonene, pyrethrins and rotenone (U. S. Industrial Chemicals, Inc.)
[c] Average 100 sweeps.

and species more clearly, the data given in tables 1 and 2 were further summarized and presented in table 4. The per cent reductions of adults and nymphs were averaged, and data for the two species of mirids were combined. Good, fair, and poor ratings were established by using the overall mean control as the numerical minimum required for a fair rating.

No insecticide used alone gave good control of the species complex in alfalfa. However, DDT, dieldrin, toxaphene, methoxychlor, Systox, heptachlor, aldrin and parathion appeared to be consistently superior to all other insecticides tested.

DDT was not effective for grasshopper control. Dieldrin, heptachlor and aldrin were poor for potato leafhopper control. Methoxychlor and Systox gave poor control of mirids. The fair leafhopper control obtained with toxaphene is questionable because data are based largely upon 1954 results, and leafhopper control with toxaphene has not been our usual experience in Wisconsin.

Since the control with parathion is inconsistent and parathion is known to have short residual effectiveness, it would appear that the best method of controlling the complex of species in alfalfa is to use a mixture of insecticides rather than depending upon any one insecticide alone. The mixture in Wisconsin must necessarily consist of an insecticide good for control of leafhoppers and an insecticide good for control of grasshoppers and mirids.

It is concluded that a mixture such as a DDT plus dieldrin is most suitable for residual control of the species complex in alfalfa. A mixture of DDT plus toxaphene,

Table 4.—Control of the potato leafhopper, mirids[a] and grasshopper nymphs by ten insecticides, and ratings.

Insecticide and Pounds Technical per Acre	Potato Leafhopper		Mirids		Grasshopper	
	All Stages Rating	Average % Control	All Stages Rating	Average % Control	All Nymphs Rating	Average % Control
DDT, 0.5	Fair	83	Good	79	Poor	32
Dieldrin, 0.25	Poor	53	Good	81	Good	99
DDT 0.5+dieldrin, 0.125	Good	92	Good	79	Good	97
Toxaphene, 0.75	Fair	79(?)	Good	76	Good	99
Methoxychlor, 1	Good	89	Poor	37	Fair	81
Systox, 0.25	Good	93	Poor	54	Fair	79
Perthane, 1	Good	91	Poor	22	Poor	57
Heptachlor, 0.25	Poor	18	Fair	72	Fair	81
Aldrin, 0.25	Poor	23	Fair	59	Good	93
Parathion, 0.33	Fair	71	Fair	67	Fair	82
Minimum % required for rating:						
Fair		71		59		75
Good		87		75		92

[a] Alfalfa plant bug and tarnished plant bug.

DDT plus aldrin, or DDT plus heptachlor should give results comparable with the DDT plus dieldrin mixture. This is indicated in the results shown in table 3 when these mixtures were tested in 1951. Good control of nymphs of the tarnished plant bug and grasshopper and fair control of leafhopper adults were obtained with the mixtures. It is expected that further testing would give similar results.

With regard to insect control for forage production where non-residual insecticides must be used, it appears at this time that methoxychlor and Perthane for leafhopper control and heptachlor and aldrin for grasshopper and mirid control would be most suitable. Although parathion is effective for the species complex, its indiscriminate use by the farmer cannot be recommended because of the acute toxicity of this insecticide. In 1954, methoxychlor plus aldrin and methoxychlor plus heptachlor mixtures and malathion as a substitute insecticide for parathion were all tested with encouraging results. It is proposed to continue research with these insecticides over a period of several years to obtain a more complete evaluation.

CONCLUSIONS.—Alfalfa, whether grown for forage or seed, has a complex of injurious insect species, the most important of which in Wisconsin are the potato leafhopper, mirids and grasshoppers. These insects are best controlled in the nymphal instars of growth.

No single insecticide has been effective for the residual control which is needed for seed production. Best results were obtained with DDT plus dieldrin or similar mixtures which utilize a good leafhopper insecticide and a good grasshopper and mirid insecticide.

For the non-residual control which is necessary for forage production, parathion appears to be fairly effective for the species complex. However, it cannot be recommended generally to the farmer because of its acute toxicity. Aside from parathion, no single insecticide was found effective for the species complex. Methoxychlor and Perthane for leafhoppers and aldrin and heptachlor for mirids and grasshoppers are good possibilities. A mixture of the two types of insecticides appears to give the most satisfactory control.

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Observations on the Decline and Growth of Honey Bee Colonies[1]

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Measurements of the quantities of brood in colonies of honey bees have been made periodically throughout the summer season by several workers, particularly by Brünnich (1922) and by Nolan (1925); but the measurement of the quantities of bees present has seemed to present somewhat greater difficulties, and although Farrar (1931) has made many measurements in the active season and also (1949) reports observations on colonies killed with cyanide in the winter, no worker seems hitherto to have presented the results of periodic measurements on single living colonies throughout the year, including the whole of the winter period.

Farrar (1934, 1936) gives the results of measurements of numbers of bees in many colonies in autumn and the following spring, but although there were several untreated colonies the majority were artificially supplied with large quantities of extra pollen which greatly altered their spring size: furthermore the author in these two papers does not attempt to evaluate the effect of Nosema disease.

The climate of Aberdeen, Scotland is sufficiently different from that of Laramie, Wyoming, in any case to justify further measurements of the same general sort, while in the present work (which does not include added pollen)

[1] Accepted for publication May 4, 1955.

a much larger number of "untreated" colonies is shown, and colonies with Nosema disease are directly compared with others definitely known to be healthy, thus affording the first clear numerical evaluation in Britain of the effect of this disease, which in general terms has been known to cause damage to colonies. Comparison on the same basis of the relative effects of double- and single-walled hives on colony strengths in spring has also been made.

METHODS.—It was found that by the technique of comparing quantities of bees on the comb with calibrated photographs, as described by Jeffree (1951), measurements accurate within a few per cent could in the climate of Aberdeen be made throughout both summer and winter without seriously disturbing the colonies. Certain conditions had, however, to be observed, particularly that in winter measurements could be made only when the screen temperature was above 42° F., and in summer measurements had to be confined to those times when few or no bees were flying, that is, particularly in early morning, late in the evening, or on dull, cold days.

The data presented in this paper were obtained sometimes by the above technique, and sometimes, when it seemed likely to afford greater accuracy, without occasioning damage, by the alternative technique of weighing each comb in turn throughout the entire hive, with bees on the combs, putting the combs temporarily in another box when weighed, and subsequently shaking all bees off, and re-weighing the combs; then weighing a sample of about 40 bees in a weighing bottle, and counting these to obtain the number of bees to the gram. Due allowance was made for any relatively small number of bees on the boxes or floor when either of these methods was used. The shaking technique was not used on those occasions in summer when unripened nectar in quantity in the combs would have been shaken out, with possible damage to the bees and error in the apparent weight.

RESULTS.—1. *Winter loss of bees in healthy and in Nosema colonies.*—In the years 1944, 1945, 1947, 1949, 1951, 1952, and 1953 several colonies were each year prepared for winter, and in late autumn (November) the quantity of bees was determined by one of the described methods, and the strengths were again similarly redetermined about 150 days later in the spring. In 50 of these, which were good normal colonies, autumn strengths lay between 9500 and 15,600 bees. Samples from these colonies were microscopically tested for Nosema and acarine diseases in the autumn, and none was found, but in the spring, when they were tested again, 30 were found to have Nosema spores while 20 were clear. The 20 colonies which remained healthy had an average autumn strength of 11,898 bees, and the mean of the losses in bees over winter (adjusted to 150 days) was 2806 ± 598 bees. The 30 which developed Nosema averaged 12,652 bees in autumn and the mean of the winter loss (150 days) was 4344 ± 501 bees. Thus the colonies which developed Nosema lost on an average 1538 more bees, which is half a British standard comb-full, in these 150 days. The Standard Error applicable to this extra loss is 784, and a t test for significance gives $t = 1.96$, with 48 degrees of freedom. Thus on these data the difference in the rates of winter loss in the two groups is mathematically barely significant.

From beekeeping experience, and also in view of other so far unpublished data in this Department, there is no doubt that an extra loss of bees in the Nosema colonies is real. The data may, however, be turned about the other way, when it forms a mathematically framed demonstration that the damage caused by Nosema during the 150 days does not exceed 3118 bees ($p = 0.05$), which, for practical purposes, is one British Standard comb-full. This result, then, seems to say that we should take neither a complacent nor an alarmist view about Nosema—it has apparently done considerable damage, but its effects on these moderately large colonies, have not been catastrophic.

2. *Effect of Nosema disease on the winter consumption of stores.*—The mean for the consumption of stores in 150 days (November to April) was 18.42 ± 1.09 lbs. for the above 20 healthy colonies, and 15.79 ± 0.59 lbs. for 27 that developed Nosema. Here we see that the Nosema colonies have consumed 2.63 lb. less stores than the ones that remained healthy. The Standard Error of this difference is 1.16 lbs., and a t test ($t = 2.27$, with 45 degrees of freedom) shows that this difference is significant at the 5% level. This result is slightly unexpected; but a possible cause could have been the relative weakness of the Nosema colonies by spring, and perhaps they may also be later starting to rear brood, and consume less stores on that account.

3. *Winter loss, consumption of stores, and Nosema disease in single- and double-walled hives.*—Of the two groups, in section 1 above, 13 were in double-walled and 37 in single-walled hives, and the means of the losses in the two groups taken this way were respectively 3873 and 3319 bees. It can be shown that the difference between these does not approach significance ($t = 0.61$). The respective consumptions of stores in the two types of hives were respectively 16.89 and 16.91 lb., which are for practical purposes identical. Thus we see no indication here that there is any difference at all between the two types of hives for wintering. The number of colonies developing Nosema disease was 8 out of 13 for the double-walled and 22 out of 37 for the single-walled hives. A χ^2 test shows that no significance can be attached to the differences between these figures, and therefore there is no indication of higher Nosema incidence in one or the other hive type.

4. *Fluctuation in numbers of bees throughout the year.*—In 1945, 1946 and 1947, numbers of bees in each of several colonies were determined throughout each year by the methods described, and the results for six substantially normal, healthy colonies are shown in the graphs (Figs. 1 to 3). Each curve shows a well-marked minimum, between March and June, and an equally or better defined maximum about June to August. The exact positions of these maxima and minima, and the shapes and dimensions of the curves, seem to depend on environmental conditions and conditions within the colony. Thus in 1947, a year with a remarkably late spring, the position of the minimum is later than in the other years. It is also apparently later in the very small colony shown in graph F, than in the larger colony shown at D, while E is intermediate. Colony F was indeed remarkably small, having only 690 bees on June 9th, and there is little doubt that it was only the exceptionally fine summer of that year which saved it.

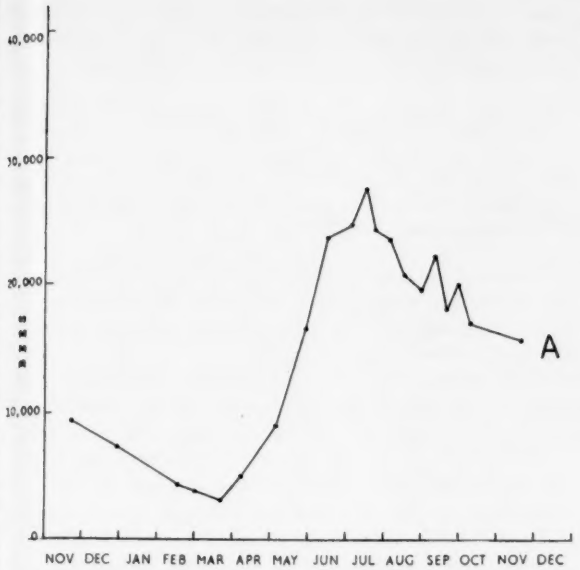

FIG. 1.—Number of bees in a colony throughout the year, 1945.

None of these colonies suffered loss of bees from swarming, though colony A swarmed with a clipped queen and the bees returned (July 3rd). It was subsequently queenless for 5 days, and even this relatively short interval of queenlessness has probably caused a reduction in the peak strength. Colony B started making queen-cells on June 20th, but these were controlled and the colony was re-queened on July 14th. Colony C was re-queened on July 17th. D made swarm preparations and was split in two parts on 21st June, but the bees in both parts have subsequently been recorded together. Colony E was found with sealed queen-cells on July 29th, and was treated by a modification of the Snelgrove technique; while F was similarly treated on August 22nd. The minimum recorded colony sizes varied from 690 to 11,640, with a mean of 5666 bees, and the maxima varied from 12,360 to 41,250, with a mean of 30,165 bees. The actual gross amount of honey harvested by these colonies (summer maximum weight of honey minus spring minimum) was respectively 42.8, 29.7, 38.7, 228.9, 132.4 and 28.0 lb., with an average of 83.4 lb. The wide fluctuation was undoubtedly influenced by differences of years and sites, colonies A, B, C and F having been kept on very poor clover sites while D and E were migrated to a particularly good bell and ling heather site. It is interesting that the colony which harvested 229 lb. of honey on a

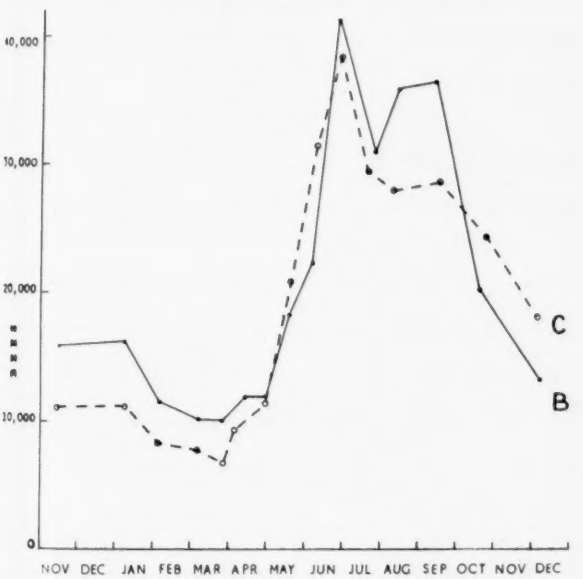

FIG. 2.—Number of bees in two colonies throughout the year, 1946.

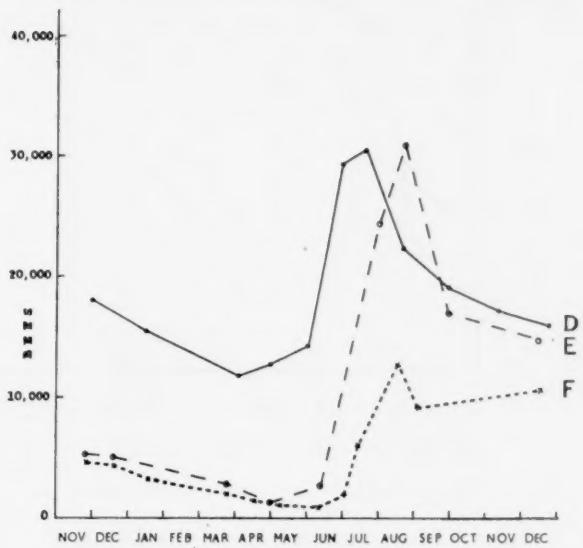

FIG. 3.—Number of bees in three colonies throughout the year, 1947.

rich site in that exceptionally fine year 1947 never much exceeded 30,000 bees, while the strongest colony, with a maximum of 41,000 bees in 1946, a very poor season, harvested only 30 lb. of honey. These may be rather exceptional figures, but it does seem possible that in a very good season the bees work themselves out too quickly to attain any very high colony size. On the other hand, beekeepers are aware of an obvious relationship that in equal environmental conditions the colonies that are largest throughout the summer yield the most honey. The present results indicate that a colony which in Aberdeenshire would be considered a really good honey-gathering unit would at its peak have 30,000 to 40,000 bees, a number smaller than has sometimes been quoted; although it is known that in really good conditions somewhat higher values are reached.

5. *Spring colony size for different values of autumn size.*—Figure 4 shows the minimum spring sizes for the above six colonies plotted against the previous November sizes. It is a fact well known among beekeepers that colonies reduced in the autumn to a very small number of bees perish during the winter—that is, spring minimum size for colonies below some critical size in autumn becomes zero. While these six colonies would be insufficient

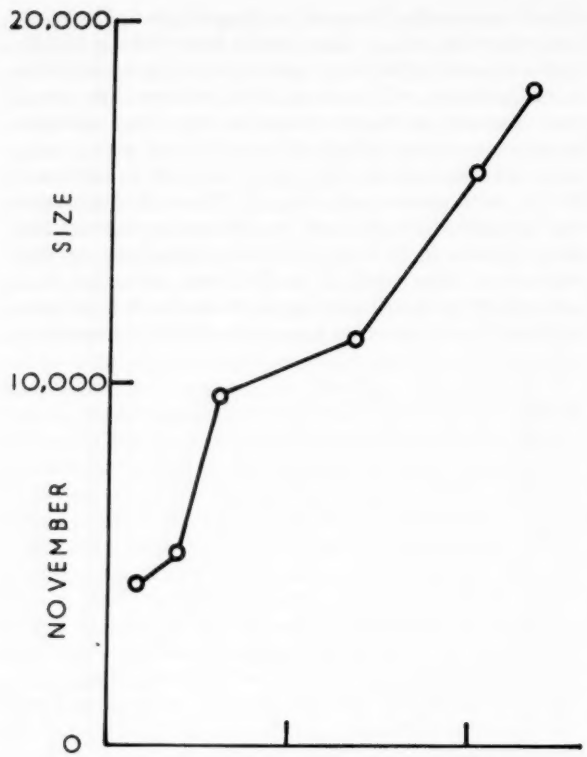

FIG. 4.—Numbers of bees in six colonies in November and the following Spring.

to establish the shape of this curve with any exactitude, they indicate that under the conditions which were here obtaining the minimum November size, for survival through the spring, might have been in the region of 4000 bees.

The percentage losses of bees in the six colonies between November and the time of the spring minimum, in order of the points shown on the graph, were 85%, 66%, 69%, 39%, 36%, and 35%. Also, the supposed smaller colony which would not have survived would have added a theoretical 100% at the beginning of the above series; and thus we see a very definite indication that within the limits shown it is not profitable to attempt to put very small colonies down to winter, since their losses of bees are relatively much greater than those for colonies of medium size.

6. *The range of sizes of colonies at Aberdeen.*—In the course of this work the smallest colony measured which subsequently survived was the one in Section 4 above with 690 bees, and the largest colony, other than any which had been artificially formed by uniting, had 47,703 bees. The mean size throughout the year of a healthy colony, based on 510 estimations, was 13,231 bees.

ACKNOWLEDGMENTS.—In concluding this paper I would like to thank Dr. D. J. Finney of the Department of Statistics, University of Aberdeen, for statistical advice; and Miss M. D. Allen, who made determinations of autumn and spring colony strengths for the 1953–54 winter, and gave valuable assistance in the computations.

SUMMARY.—Over several years, measurements of numbers of bees in colonies were made, in some instances by direct weighing, in others by the technique of comparison with calibrated photographs.

From estimations of 20 colonies in late autumn and the following spring, the rate of loss of bees is given for normal healthy colonies over winter. Thirty similar colonies with Nosema showed an appreciably higher rate of loss. The consumption of stores was somewhat less for the Nosema than for the healthy colonies. Double-walled hives showed no advantage over single-walled in respect of loss of bees, consumption of stores, or incidence of Nosema disease.

From successive determination of numbers of bees in six other colonies throughout the winter and the following season, complete curves of winter decline and summer rise in colony strengths are given. Yields from these colonies are quoted and discussed. Results indicate that a good honey-gathering colony in Aberdeenshire would at its peak have 30,000 to 40,000 bees.

Spring sizes are shown in relation to November sizes, and a minimum size for survival through the winter is indicated. It is shown that medium-sized colonies lose relatively fewer bees over winter than do very small colonies.

The range of sizes of colonies measured at Aberdeen, Scotland, is indicated.

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Further Studies on the Ovicidal Action of Parathion to Eggs of the Peach Tree Borer[1]

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The toxicity of parathion to the egg stage of insects has been reported by a number of workers. While frequent reference is made to ovicidal action incidental to control studies, relatively little attention has been given to the manner in which lethal effects are induced. Investigations along this line have been conducted by Holz (1949), Schwartz (1950), Speyer (1950), Lord & Potter (1951), Staudermayer (1953), Schuhmann (1953) and others.

The ovicidal action of parathion to eggs of the peach tree borer, *Sanninoidea exitiosa* (Say), has been of particular interest since it has been shown that field control is due largely to this action (Smith 1954). Bark residues remained ovicidally effective for two or more weeks after treatment, and advantage was taken of this fact in eliminating the late larvicidal sprays which had proved impractical. Examination of eggs killed by exposure to parathion revealed that embryological development continued apparently normally until near the time of hatching but the embryo failed to emerge. This condition prevailed even though eggs remained in contact with the treated surface for only the first 2 days of the incubation period lasting 10 days or more. Aside from the practical significance of these findings several questions of a more fundamental nature arise. When does the toxic effect of treatment occur and in what stage of development is the embryo most susceptible? The first question was investigated by determining the respiratory rate of treated eggs assuming that interference with vital physiological systems would be reflected in the metabolic rate of the organism.

With respect to the second question, that of susceptibility, it seems likely that considering the drastic physiological changes occurring in the course of embryonic development, differences in susceptibility would exist and that the establishment of these might be suggestive of the mode of action involved in poisoning. Investigations of susceptibility were conducted under laboratory conditions using methods designed to simulate exposure under field conditions.

Experimental Methods.—*Test species.*—As the eggs of a number of species respond similarly to parathion treatment considerable latitude existed in the choice of a test species for these studies. The peach tree borer was selected for several reasons. First, in actual practice ovicidal action of parathion plays a major role in effecting control. In addition, the oviposition habits of the species and its response to laboratory handling meet the requirements of this study. Sufficient quantities of eggs of known age can be obtained as individual females deposit several hundred eggs in the course of a day. Eggs are handled with ease, being laid singly and readily removed from the surface on which deposited. Viability of eggs of the species is high, over 95 per cent, and the incubation period is relatively long, 8.5 days at 80° F., permitting detailed observation of developmental stages. The chief disadvantage in the use of this species lies in its short period of moth emergence. Under local conditions this period extends for approximately 6 weeks commencing in mid-July. Efforts to provide eggs over a longer period by holding pupae at low temperature were unsuccessful due to the failure of the males to mate under laboratory conditions.

In providing material for testing, quantities of pupae were collected from the field. Pupal cases containing pupae were placed individually in cells formed in moist sand and held in an insectary pending emergence of moths. Several hours after emergence the females were taken to peach orchards and mated with males lured by the scent of the females. Upon completion of mating the females were placed individually in paper bags (Kraft #1) and held at 80° F. Each day the moths were transferred to a new bag. The paper bearing eggs was soaked in water for several minutes after which the eggs were counted and scraped into watch glasses.

Measurement of respiration.—The Warburg constant-volume respirometer equipped with specially designed flask was used. The flasks (Fig. 1) were designed by G. W. Pearce, E. L. Clark and the writer for use in related studies (Clark 1952). This design possessed several distinct advantages. Experimental material could be introduced and removed with ease. Volume was adjustable to accommodate various types of material. The plastic (Plexiglass, Rohm and Haas Co.) could be machined to standard volume specifications for direct comparison studies, a feature not possessed by glass flasks. In these tests the total volume of flasks reduced by inserts was approximately 8.5 cc. The instruments were calibrated with mercury as outlined by Umbreit *et al.* (1945). Absorption of CO_2 was accomplished by the addition of 0.5 ml. KOH(10%) and 0.5 ml. of distilled water was added to the other well. For respiratory determinations samples consisting of 500 eggs deposited over a 24-hour period were used. The eggs were held in a small plastic cylinder which could be handled with ease. Temperature was maintained at 80° F. by a controlled water bath. The sealed flasks were allowed to equilibrate for 1 hour before closing the manometers after which readings were taken at half-hour intervals over a period of several hours. Upon completion of readings each day eggs were removed and held at 80° F. At this temperature approximately 8.5 days were required for completion of incubation.

Ovicidal Treatment.—Under conditions of actual usage ovicidal action results from exposure to the toxicant in two ways, i.e., by direct application of the toxicant to the chorion of the eggs and by the toxic effect of residue adhering to the treated surface on which eggs are later deposited. In these studies tests were designed to simulate both of these conditions. Eggs were treated directly

[1] Journal Paper No. 1004, New York State Agricultural Experiment Station, Geneva, New York, April 29, 1955. Accepted for Publication June 10, 1955.
[2] The author wishes to acknowledge the helpful advice of Dr. Leigh E. Chadwick in the preparation of this manuscript.

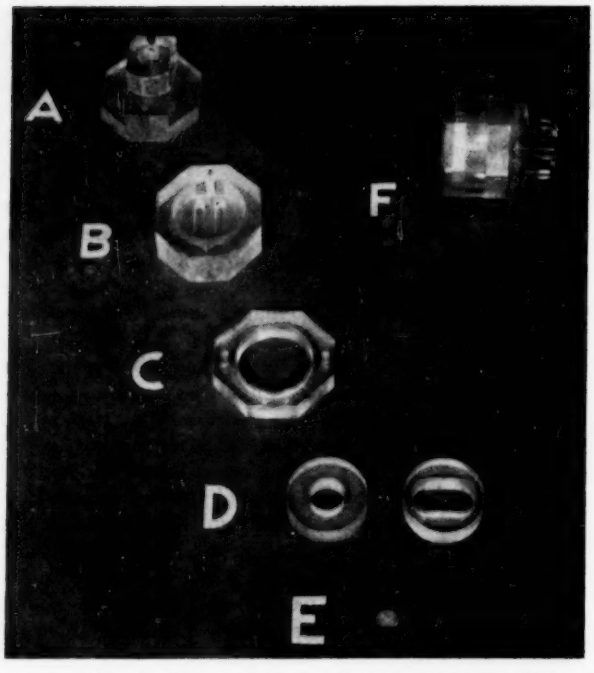

FIG. 1.—Plastic Warburg flask used for determining respiratory rate of peach tree borer eggs. A. top with tapered joint to fit manometer connection. B. base provided with parallel wells for reagents. C. spacer ring for increasing volume. D. inserts used to decrease volume. E. plastic cylinder for holding eggs. F. assembled flask

by immersing them for 2 minutes in a water suspension of the toxicant. To insure wetting, eggs were stirred with a camel's-hair brush. Exposure to residues was accomplished by sandwiching eggs between sheets of dry filter paper (#2, 9 cms.) which had been impregnated by dipping in a suspension of parathion emulsion (0.035%).

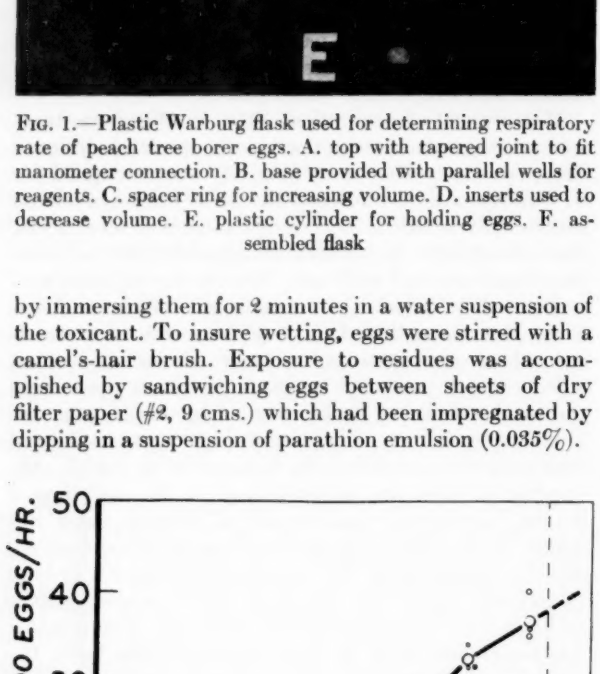

FIG. 2.—The normal respiratory rate of peach tree borer eggs. The line connects the average rate determined from the individual readings shown.

EXPERIMENTAL RESULTS.—*Respiratory studies.*—The normal respiratory rate was determined by taking daily readings on several groups of eggs for the duration of the incubation period. In addition, one or more determinations were made on groups of eggs being held for later treatment. These determinations and the curve plotted for the average of these values are shown in Fig. 2. The respiratory rate increased by approximately fivefold during the course of incubation. Considerable variation in the rate of different samples is noted, a situation apparently normal in studies of this type. As would be expected, the curve plotted from the average values is of more uniform slope than that of individual lots. In a number of cases individual lots showed little or no gain in rate on successive days. When this was observed it occurred between the second and fourth days of the incubation period. The suggestion that the normal curve was characterized by a uniform rate of several days duration was not clearly

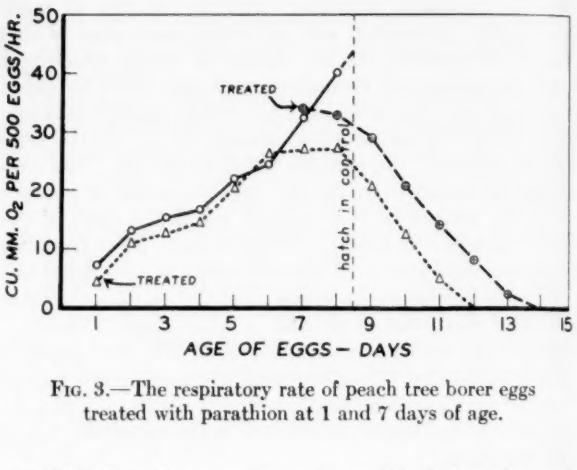

FIG. 3.—The respiratory rate of peach tree borer eggs treated with parathion at 1 and 7 days of age.

established, such an occurrence possibly being obscured by the variable age of the eggs within the individual samples. Readings made after hatching commenced were of questionable accuracy as newly hatched larvae found their way into the reagent well and were killed. Despite these limitations the method employed proved well adapted for this study.

The effect of direct contact treatment on the respiratory rate of eggs treated at 1 and 7 days of age is shown in Fig. 3. Similar treatments were made on eggs of 2, 3, 4, 5 and 6 days of age. In all cases the response was essentially the same; namely that the rate continued normally following treatment until approximately 1 day prior to the time hatching would normally occur, at which time the rate ceased to increase and gradually declined. While differences in the various curves are slight they suggest that eggs treated earliest begin to decline sooner and cease to respire earlier.

It was thought that concentrations of toxicant well above the lethal threshold might produce more pronounced effects on the respiratory rate. The results of tests using higher concentrations are given in Fig. 4. The response of eggs to treatment with all concentrations was similar although it appeared that the higher concentrations resulted in earlier decline and cessation of respiration. Thus, the influence of prolonged exposure or higher

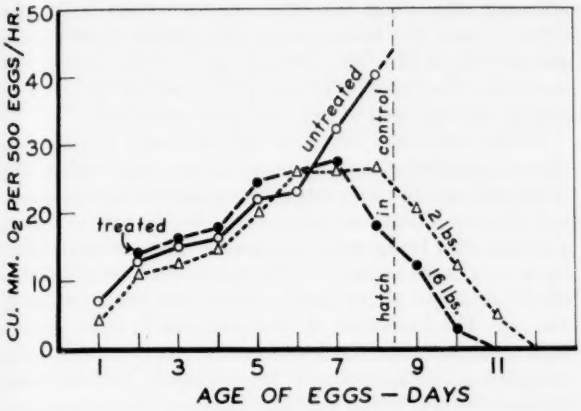

FIG. 4.—The influence of excessive dosages of parathion on the respiratory rate of peach tree borer eggs.

concentration appears to be similar within rather narrow limits.

As the respiratory response was essentially the same irrespective of stage of development when treatment was made no conclusive evidence was provided relative to the time that lethal action took place.

Susceptibility of eggs at various stages of development. The results of direct contact treatments are given in table 1. Treated in this manner, eggs in the later stages of development were most susceptible. The sharpest break in susceptibility came between 4 and 5 days of age with little difference before and after. A comparison of respiratory rates at various stages shows no marked changes coincident with differences in susceptibility. The embryological changes which might coincide with variable susceptibility have not been determined.

Further tests were undertaken to determine whether wettable powder and emulsified formulations of the toxicant were equally effective. These results are given in table 2. The wettable powder formulation was decidedly more effective than the emulsion. This difference could conceivably result from heavier initial deposit or slower rate of weathering by the wettable powder.

The susceptibility determined by residue exposures is shown in table 3. Treated in this manner, susceptibility was greatest in the early stages, the reverse of the relationship by direct contact treatment. Sharp differences between the first two age groups were not disclosed by these tests because most of the exposures were above the lethal threshold. In the last three groups a progressive decrease in susceptibility with age is apparent.

While results obtained by the two methods appear to be in conflict, exposure to residue is believed to reveal more clearly the true physiological susceptibility of the organism, being less influenced by factors of a physical nature such as deposit and rate of weathering.

DISCUSSION.—Two aspects of ovicidal action have been considered here: 1) the effect of treatment on the respiratory rate of developing eggs, and 2) the stage of embryonic development most susceptible to treatment. The respiratory rate of eggs treated at all stages responded similarly, declining after the seventh day.

The respiratory studies reported here closely parallel the investigations of Staudermayer (1953) using eggs of the silk worm, *Bombyx mori*. Our findings are in general agreement with one exception. The temporary rise of "revival" in respiratory rate several days after the normal time of hatching which was reported for eggs of the silkworm was not observed in eggs of the peach tree borer.

The continued development of the embryo after exposure could be explained in two ways. One, action by parathion occurs immediately after gaining entry to the egg but this action does not prove lethal until embryonic development nears completion. Two, parathion taken up at any stage of development is retained in the egg until the late stages when enzymatic development becomes favorable to its action. In considering the delayed action of parathion applied directly to eggs of several species Speyer (1950) concluded that lethal exposure occurred as the larvae encountered surface residue in chewing out of the chorion. Schuhmann (1953) in similar studies using eggs of *Laspeyresia* (*Grapholitha*) *funebrana* Tr. concluded that "the ester is dissolved in the egg shell and the young larvae are poisoned on attempting to emerge." Neither

Table 2.—The influence of formulation on the effectiveness of parathion to two-day-old peach tree borer eggs by direct treatment.

Wettable Powder		Emulsion	
Concentration (p.p.m.)	Per Cent Kill[a]	Concentration (p.p.m.)	Per Cent Kill[a]
5.5	2	425	4
11	45	850	47
22	100	1700	93
45	100	3400	100

[a] Approximately 100 eggs treated at each concentration.

Table 1.—The influence of age on susceptibility of peach tree borer eggs[a] to parathion emulsion by direct contact treatment.

Concentration (p.p.m.)	Per Cent Kill						
	Age of Eggs (Days)						
	1	2	3	4	5	6	7
425	4	29	59	10	96	96	100
850	47	64	76	51	93	79	100
1700	93	99	93	87	98	100	100
3400	100	100	100	98	99	100	100

[a] Approximately 100 eggs treated at each concentration and each date.

Table 3.—The influence of age on susceptibility of peach tree borer eggs exposed to parathion residue.

Exposure Time in Hours	Age of Eggs—Per Cent Kill[a]			
	1 Day	3 Days	5 Days	7 Days
12	84	77	40	2
24	100	100	30	1
36	100	100	54	1
48	100	100	100	—

[a] Approximately 100 eggs used in each exposure.

of these hypotheses seems in agreement with the evidence cited here.

Lord & Potter (1951) in studies of ovicidal action report that high concentration of materials containing tetraethyl pyrophosphate caused death before visible embryonic development had taken place. In the present work concentrations of parathion well above those used under practical conditions failed to arrest development in early stages. The possibility exists that high concentrations as employed in the work cited above involve modes of action which do not occur under conditions of actual usage.

Susceptibility was found to be highest at late stages of development when treated directly. By residual exposure the relationship was reversed, early stages being most susceptible. As indicated earlier residual exposure is believed to reveal more clearly the true physiological susceptibility of the organism. Irrespective of the method of treatment, i.e. direct application or residual exposure, parathion likely gains entry in the vapor form. It has been established by the writer (unpublished data) that exposure to vapor alone proved lethal to eggs of the oriental fruit moth, *Grapholitha molesta* (Busck), another species highly susceptible to ovicidal action of parathion. If parathion enters the egg as vapor in the gaseous exchange of the respiratory process, a positive relation between respiratory rate and susceptibility might be expected. This was not the case, eggs having the highest respiratory rate being less susceptible. This fact could be accounted for by change in permeability, the egg presumably becoming less permeable with age and consequently less susceptible. The extensive studies of Salkeld & Potter (1953) are of interest along this line although their work did not include tests with parathion.

The question of susceptibility ultimately focuses attention on the biochemical systems involved in toxic action. The toxicity of organophosphorus compounds to mammals and hatched insect forms has been attributed to the inhibition of cholinesterase which prevents an accumulation of acetylcholine in the nervous system. (Mazur & Bodansky 1946, Chadwick & Hill 1947, Metcalf & March 1949). It has not been established that the same mode of action accounts for ovicidal effectiveness. In attempting to apply this scheme to ovicidal action differences in the physiological systems of eggs and hatched forms must be considered. Cholinesterase might not be present in undifferentiated eggs and if present is likely of no physiological importance until the nervous system becomes functional. Either the absence of the enzyme in early stages or its non-essential role at this time can be reconciled with experimental evidence whereby mortality occurs at late stages regardless of the stage at the time of treatment. Still another possibility is that the toxic action is not due to parathion as such but to its metabolites and the enzymes necessary for such metabolism are not present until the late stages of development.

It is apparent that further studies on the esterase systems of developing eggs will be required to provide conclusive evidence on the questions raised. Of interest in this connection is the difference in susceptibility to parathion by eggs of various species. In addition to the peach tree borer a high degree of susceptibility has been found in the oriental fruit moth, *Grapholitha molesta* (Busck), the plum curculio, *Conotrachelus nenuphar* (Hbst.), and the lesser peach tree borer, *Synanthedon pictipes* (G. & R.). By contrast, eggs of the large milkweed bug, *Oncopeltus fasciatus* (Dall.), are not affected by parathion treatment at practical concentrations.

While conclusive evidence has not been provided to clearly establish the mechanism of ovicidal action, the observations cited here might be reconciled by the following scheme: Parathion gains entry to the egg as vapor, younger eggs being more permeable. The toxicant taken up at any stage remains in the egg as such or is metabolized to a more active anticholinesterase that persists in the egg. The inhibition of cholinesterase is of no physiological importance until embryonic development nears completion at which time it proves lethal. The depressed respiratory rate which continues beyond the normal time of hatching is likely a secondary effect of poisoning.

SUMMARY.—In considering the ovicidal action of parathion to eggs of the peach tree borer, the respiratory rate of treated and untreated eggs was determined. Eggs treated at all stages of development continued to respire normally until the seventh day declining progressively thereafter for several days beyond the normal time of hatching.

Early treatment with concentrations in excess of the lethal threshold did not arrest development until the late stage of embryonic development. Susceptibility to parathion residue was highest in the early stages.

While the mechanism of ovicidal action has not been clearly established the following scheme is tentatively proposed:

Young eggs are more permeable to parathion vapor. The toxicant taken up by the egg is retained as such or metabolized to a more active anti-cholinesterase. Its inhibitory action does not prove lethal until embryonic development nears completion. The extended sub-normal respiratory rate is likely a secondary effect of poisoning.

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Larvicides for Control of the House Fly[1]

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The chlorinated hydrocarbon and phosphate insecticides have been extensively investigated and widely used against the adult house fly, *Musca domestica* L., but relatively few studies with these materials have been made against house fly larvae. Entomologists have questioned the use of these toxicants in practice because of a faster development of resistance when both adults and larvae are exposed to the material (Bruce & Decker 1950).

Before the discovery of DDT, the larval habitat offered the most promising point of attack in controlling the house fly. Because of the high toxicity of DDT to the adult house fly, a complete revision in control procedures was adopted with emphasis on the elimination of adult flies. Despite the shift from larval to adult fly control, the need for a good house fly larvicide still exists. Although toxicological investigations have proved that various chemicals are extremely toxic to house fly larvae, most of them have no practical use as house fly larvicides. This study was undertaken in the hope of providing some basic avenues by which adult house fly control may be supplemented, if not attained, through larval control.

The choice of materials to be tested was made on the basis of several considerations. Toxicity, though important, was not the sole factor used for selecting the test chemicals. Phytotoxicity, mammalian toxicity, cost, and availability were other factors considered to be of equal significance.

Throughout these investigations a stock colony of the CSMA Strain of house flies, was maintained for egg production. The temperature of the rearing room was 80° to 85° F., and the R. H. 50 to 60 per cent. The third instar test larvae were reared from eggs oviposited by the stock colony. The larvae were reared on a media which was a slight modification of the standard NAIDM house fly larval media (Anonymous 1955) and consisted of alfalfa, bran, brewer's yeast, malt, mycoban[4] and water. A fresh supply was made every 2 days. Battery jars, 12 inches in height and 6 inches in diameter, were used as larval rearing containers. The jars were filled two-thirds full with the larval food mixture and subsequently inoculated, 2 inches below the surface, with approximately 2000 eggs. Ninety-six hours after the eggs hatched the larvae were in the third instar and averaged about 11 millimeters in length. In the newly transformed larvae, the dark brown intestinal contents were clearly visible through the integument, but could not be seen in larvae 24 to 36 hours older. In addition, the newly transformed larvae were usually found far below the surface of the larval media actively ingesting the food mixture. The larvae 24 to 36 hours older were usually less active, seemed to have been eating less food, and were almost always found in the upper 2 inches of the larval media, close to the site of pupation. For the test larvae to get an adequate exposure to the toxicants under study, it was important to use the newly transformed larvae (96 to 108 hours old).

Following the work of McGovran & Piquett (1945), the larval rearing media were used for test purposes. The total weight of the ingredients in the test media for each concentration duplicate was 200 grams. The larval test media were prepared separately for each duplicate at each concentration with all tests. The dry media were weighed in 75 gram lots, and put in appropriately marked containers. The aqueous part of the test medium was prepared in large quantities by intimately mixing together the water, malt, and yeast. The 125 cubic centimeters necessary for a test concentration duplicate were taken from this mixture. The toxicants for each concentration duplicate were determined and added to the aqueous part of the test media. This mixture was then thoroughly agitated and added to the dry media, after which the dry and aqueous parts were thoroughly mixed.

All doses or concentrations used were calculated on the basis of parts of toxicants per million parts of test media. The emulsifiable concentrate formulations and the water soluble technical powder, Bayer L 13/59, were diluted with water to low percentage (0.125% to 1.0%) solutions before adding to the aqueous part of the test media. The wettable powders and emulsions were added to the aqueous part of the media in their original commercial formulations.

[1] Accepted for publication May 2, 1955. The data in this paper are taken, in part from a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Entomology, Cornell University, Ithaca, New York.

[2] Acknowledgment is made to H. H. Schwardt for his guidance and assistance throughout the investigation and in the preparation of this manuscript. The author is also indebted to J. E. Dewey for suggestions and criticisms on the laboratory methods and for assistance in analyzing the data.

[3] Now with Southern University, Baton Rouge, Louisiana.

[4] Sodium propionate, approximately ¼ pound to 100 pounds of dry larval media.

Test larvae 4 to 4½ days old, were selected for each test from two larval rearing jars, which had been inoculated with eggs oviposited by adults in four different cages. The larvae were separated from the larval rearing media by putting the larval rearing jars beneath a light 8 inches from the surface of the larval media. At approximately 2-minute intervals, about 1 inch of the surface larval media was removed. The larvae, being negative phototropic, immediately burrowed further downward in the media. This process was repeated until all the larvae were concentrated on the bottom of the container. The two groups of larvae were then put in one container and from this consolidated group, using a wooden probe, 50 larvae were counted into the respective test containers.

During the preliminary tests it was observed that larvae in the check treatments, with many of the chemicals, would pupate and emerge several days before those in the test treatments. This seems to have been more pronounced with the chlorinated hydrocarbons than with the phosphates. On the basis of these observations, a holding period of 14 days was selected. Check treatments were run with all tests in order that proper adjustments could be made for the natural mortality occurring in the test treatments. The criterion of larval mortality was based on the emergence of morphologically normal flies from the pupae of test larvae. From this count of the adult flies, the percentage larval mortality was determined. The combined average check larval mortality occurring in all tests during these investigations was 9.2 per cent. All chemicals tested in these investigations were replicated six times at eight concentrations in geometrical progression. One hundred third-instar larvae per concentration or 50 test larvae per concentration duplicate were used in each replicate. Therefore, in the final series of tests, each chemical was tested 96 times, with a total sample size of approximately 4800 third-instar larvae.

The Finney (1952) method of probit analysis was used for computing the larvicidal effectiveness of the chemicals investigated in the final series of tests. The observed percentage of larval mortality in the treatments was corrected or adjusted against the corresponding mortality in the check treatments by the use of Abbott's formula (Abbott 1925). The resulting net percentage larval mortality data were used in the probit analysis computations.

Preliminary tests were run on all chemicals to ascertain whether or not they were larvicidal and to determine which of these materials were to be subjected to further investigation. In the initial preliminary screening tests all chemicals not producing 100 per cent larval mortality at 500 p.p.m. were considered non-larvicidal and were subjected to no further testing. The dose or concentration, 500 p.p.m., was chosen as the criterion for accepting or rejecting chemicals for further investigation. The results of the preliminary tests are shown in table 1.

Using the preliminary test larval mortalities as a guide, eight concentrations evenly spaced on a logarithmic scale within a range of 20 to 90 per cent mortality were selected for the final tests. The testing procedures used for the final tests and the conditions under which they were carried out were the same as those used for the preliminary tests. Throughout this investigation, no significant change in susceptibility of the test larvae occurred from

Table 1.—Preliminary results of toxicity tests with 25 formulations of 15 chemicals producing mortality[a] to third-instar larvae at or below 500 parts per million.

Chemicals and Formulations	Per Cent Mortality at Following Concentrations of Actual Material in P.P.M.											
	500	250	125	62.5	31.25	15.62	7.81	3.90	1.95	0.975	0.487	0.243
Aldrin, 23% Emul.	100	100	100	100	100	100	100	100	97	48	19	
Aldrin,[b] 40% W. P.	100	100	100	100	100	100	100	34	5			
Bayer 21/199, 10% Emul.	100	100	100	100	100	100	69	54	7			
Bayer 21/199, 50% W. P.	100	100	100	100	100	80	40	25	6			
Bayer L 13/59, 10% Misc.	100	100	100	100	100	99	89	49	33	8		
Bayer L 13/59, Tech. W.S. Powder	100	100	100	100	100	100	100	100	52	17		
BHC, 25.5% Emul. (35% gamma isomer)	100	100	100	83	39	8						
BHC, 30% W. P. (6% gamma isomer)	100	100	54	20								
Chlordane,[b] 75% Emul.	100	100	100	98	58	7						
Dieldrin, 18.5% Emul.	100	100	100	100	100	100	100	100	80	39	16	
Dieldrin,[b] 25% W. P.	100	100	100	100	100	100	100	18				
Diazinon, 25% Emul.	100	100	100	100	100	100	100	100	91	53	19	
Diazinon,[b] 25% W. P.	100	100	100	100	100	100	100	77	20			
Diazinon,[b] Tech. Oil Sol.	100	100	100	100	100	100	100	100	100			
Dilan,[b] 25% W. P.	100	100	100	100	100	100	100	87	43	16		
Endrin, 18.5% Emul.	100	100	100	100	100	98	84	52	9			
EPN-300, 25% W. P.	100	100	100	100	100	100	100	100	100	58	30	17
Heptachlor,[b] 2.5% W. P.	100	100	100	100	100	100	100	67	48	35	36	24
Lindane, 20% Emul.	100	100	100	100	96	48	27	3				
Lindane, 2% W. P.	100	100	100	100	95	42	19					
Malathion, 57% Emul.	100	100	100	100	100	97	63	50	19			
Malathion, 25% W. P.	100	100	100	100	100	85	37	13				
Parathion, 1% W. P.	100	100	100	100	100	100	100	100	100	65	32	7
Toxaphene,[b] 40% W. P.	100	100	100	82	29							
Toxaphene,[b] 58% Misc.	100	100	100	100	52	20						

[a] Mortality in treatments not corrected (Abbott's formula) for natural mortality unless mortality in corresponding checks exceeded 5 per cent.
[b] Materials subjected only to preliminary tests.

one generation to the next. Where slight variations in susceptibility did occur in test larvae, from generation to generation, they were not statistically significant.

During both the preliminary and final tests, larvae in the check treatments were observed to pupate and emerge 24 to 36 hours before larvae in the treatments. The reason for this increase in life cycle duration of larvae in the treatments is not completely understood. However, it is believed that the metabolic rate of the whole organism was decreased by the toxicant, resulting in a total increase in its life cycle. This increase in life cycle seems to have been more pronounced with those larvae exposed to the chlorinated hydrocarbon chemicals.

With the exception of formulations of BHC and lindane, all chemicals investigated in the final series of tests produced an LD50 below 8.70 p.p.m. to the test larvae. Aldrin emulsion was superior in toxicity to all other chemicals tested, producing an LD50 at 0.90 p.p.m. EPN-300 wettable powder and Diazinon emulsion were almost as toxic as aldrin emulsion, producing an LD50 at 0.92 p.p.m. and 0.98 p.p.m., respectively. Parathion wettable powder and dieldrin emulsion were about equal in toxicity. The former produced an LD50 at 1.21 p.p.m. and the latter at 1.18 p.p.m. Bayer L 13/59 technical water soluble powder was more toxic than Bayer L 13/59 water miscible, LD50 values being 2.67 p.p.m. and 3.39 p.p.m., respectively. Bayer 21/199 emulsion was almost twice as toxic as Bayer 21/199 wettable powder. The emulsion formulation of Bayer 21/199 produced an LD50 at 4.66 p.p.m. and the wettable powder formulation at 8.38 p.p.m. The malathion formulations, wettable powder and emulsion, were almost identical in toxicity to the corresponding formulations of Bayer 21/199. Malathion wettable powder produced an LD50 at 8.65 p.p.m. and the malathion emulsion at 4.83 p.p.m. Endrin emulsion, LD50 at 4.73 p.p.m., was almost as toxic as the malathion emulsion (Table 2).

Of the five chemicals tested in different formulations, wettable powder, water soluble powder and emulsions, the toxicity of the lindane formulations, wettable powder and emulsifiable concentrate, differed less than corresponding formulations of other materials. The LD50 of lindane emulsion was 11.55 p.p.m. and the lindane wettable powder was 14.80 p.p.m. The pronounced difference in the LD50 values between BHC emulsion, 50.9 p.p.m., and benzene hexachloride wettable powder, 121.9 p.p.m., is obviously due to the difference in the percentage of gamma isomer in the two formulations.

SUMMARY.—Twenty-five formulations of 15 chlorinated hydrocarbon and phosphate insecticides were investigated to determine their toxicity to third-instar larvae of the house fly, *Musca domestica*. The chemicals investigated were selected on the basis of results obtained from preliminary screening tests.

With the exception of formulations of BHC and lindane, all chemicals investigated in the final series of tests produced an LD50 below 8.70 p.p.m. Aldrin emulsion produced an LD50 at 0.90 p.p.m. and was superior in toxicity to all chemicals investigated. EPN-300 wettable powder and Diazinon emulsion were almost as toxic as aldrin emulsion, producing an LD50 at 0.92 p.p.m. and 0.98 p.p.m., respectively. BHC emulsion, LD50 at 50.9 p.p.m., and BHC wettable powder, LD50 at 121.9 p.p.m., were the least toxic of the chemicals investigated.

Table 2.—The calculated LD50 and LD95, in parts per million, of test chemicals, and their 0.05 fiducial limits, to third-instar larvae of the house fly.

CHEMICALS AND FORMULATIONS	LD50	VAR.[a]	LD95	VAR.[a]
Aldrin, 23% Emul.	0.90	0.10	3.61	0.12
Bayer 21/199, 10% Emul.	4.66	0.11	19.05	0.13
Bayer 21/199, 50% W. P.	8.38	1.12	46.41	1.55
Bayer L 13/59, 10% Misc.	3.39	1.04	15.32	1.10
Bayer L 13/59, Tech. W. S. Powder	2.67	0.11	11.28	0.16
BHC, 24.5% Emul. (35% gamma isomer)	50.90	1.00	210.40	1.20
BHC, 30% W. P. (6% gamma isomer)	121.90	1.02	298.90	1.06
Dieldrin, 18.5% Emul.	1.18	0.10	3.20	0.11
Diazinon, 25% Emul.	0.98	0.15	5.31	0.14
Endrin, 18.5% Emul.	4.73	1.07	12.49	1.22
EPN-300, 25% W. P.	0.92	0.01	2.06	0.01
Lindane, 20% Emul.	11.55	1.03	46.16	1.09
Lindane, 2% W. P.	14.80	1.12	44.62	1.31
Malathion, 57% Emul.	4.83	1.02	14.11	1.12
Malathion, 25% W. P.	8.65	1.12	28.78	1.45
Parathion, 1% W. P.	1.21	0.10	2.27	0.11

[a] The variations may be expected to fall within this range 19 chances out of 20.

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Peach Insect Investigations at Fort Valley, Georgia, During 1954[1]

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This paper reports investigations on the plum curculio, *Conotrachelus nenuphar* (Hbst.), the peach tree borer, *Sanninoidea exitiosa* (Say), and the lesser peach tree borer, *Synanthedon pictipes* (G. and R.), at Fort Valley, Georgia, during 1954.

PLUM CURCULIO.—Laboratory experiments with insecticide dusts worked into the soil for plum curculio control, initiated in 1952 and expanded in 1953 (Snapp 1953, 1954), were continued in 1954 by reinfesting with plum curculio larvae the soils treated in the preceding years. From 187 to 200 larvae were used in each test. The results, given in table 1, show that 2-year-old applications of aldrin and dieldrin and 1-year-old applications of heptachlor were highly effective in preventing plum curculio larvae from developing into adults and emerging, but that a 1-year-old application of isodrin was less effective.

In a laboratory experiment initiated in the spring of 1954, aldrin worked into the soil at the rate of 4 pounds per acre was highly effective against the immature stages of the plum curculio, and much more so when it was applied in a 2 per cent granulated formulation (30 to 60 mesh) than as an emulsifiable concentrate containing 2 pounds per gallon.

In a field experiment aldrin dust was applied to the soil beneath 1464 Elberta peach trees in replicated plots at the rate of 4 pounds per acre. All trees in the treated plots and in comparable plots in which the soil was not treated were sprayed alike for insect and disease control. Jarring of sample trees indicated that the soil treatment was of some benefit, for more curculios were obtained in the untreated plots. There was also a difference favoring the soil treatment in the infestation in the fruit at harvest. Further checks to evaluate the treatment will be made in 1955.

Field spray experiments were continued by the methods outlined in earlier papers (Snapp 1947, 1952). All applications, unless otherwise indicated, were made with a high-pressure hydraulic sprayer. Several schedules were used, as follows:

A—Petal fall, shuck off, 2 weeks after shuck off, 4 weeks and 2 weeks before harvest.
B—Shuck off, 2 weeks after shuck off, 4 weeks and 2 weeks before harvest.
C—Dieldrin at petal fall, shuck off, and 2 weeks after shuck off and parathion 4 weeks and 2 weeks before harvest.
D—Petal fall, shuck off, 2 weeks after shuck off, and 4 weeks before harvest.

In one series of tests in an orchard of Southland peaches there were four 36-tree replicates of each treatment in a randomized setup of plots. The insecticides used and the results are shown in table 2. Under the conditions of infestation that prevailed in these plots, the parathion, malathion, and dieldrin-parathion schedules gave good control.

In a second series of tests, on the Sullivan's (early) Elberta variety, there were 8 replicates of 13 treatments and a check in a randomized setup of single-tree plots. Materials and quantities used were as given in tables 2 and 4. In addition 25% EPN, was used at 1.5 pounds of a wettable powder per 100 gallons in 5 applications. Only 4.5 per cent of the harvested peaches from untreated trees were infested. Parathion with and without the petal-fall application, malathion, aldrin, dieldrin alone and in split schedules with parathion, lead arsenate, EPN, heptachlor and CS-728 (1-*p*-chlorophenyl-2-nitro-1-phenylpentane) all gave control. Endrin failed to give good control.

In a third series of orchard tests on large replicated plots, a 2X concentrated parathion spray applied with a mist blower was compared with a dilute parathion spray applied with a conventional sprayer. A five-application schedule was used. The results given in table 3 show the dilute spray to be the more effective.

Table 1.—Per cent emergence of plum curculio adults from larvae in soil treated with insecticide dusts in 1952 and 1953.[a]

TREATMENT	POUNDS OF ACTIVE INGREDIENT PER ACRE	REPLICATE 1	REPLICATE 2
Soil treated May 2, 1952			
Aldrin 2.5%	2	0	1.6
	4	1.0	1.6
Dieldrin 1.5%	2	2.5	2.1
	4	1.5	1.1
Soil treated May 28, 1953			
Heptachlor 25%	4	0	—
Isodrin 2%	4	5.8	—
Check (untreated)	—	57.0	27.3

[a] Larvae placed in soil from April 23 to June 2, 1954.

Residue analyses on samples of ripe peaches from certain of the plots are given in table 4. The results indicate that use of such chlorinated insecticides as aldrin, dieldrin and heptachlor must be limited to the early part of the spray season to avoid the danger of exceeding present tolerances. Harvest residues of malathion appear to present no problem.

Several new insecticides were given a preliminary evaluation in cage tests by methods previously described (Snapp 1947). The treatments used and the effectiveness of fresh deposits of them against plum curculio adults are given in table 5. All materials included in the tests showed promise.

The residual value of the materials included in the

[1] Accepted for publication May 4, 1955. Presented at the meeting of the Cotton States Branch of the Entomological Society of America held at Tampa, Fla., Jan. 17–19, 1955.

[2] Julius P. Hollon assisted with the experiments reported in this paper.

Table 2.—Results of orchard experiments for the control of the plum curculio on Southland peaches, 1954.

Insecticide (Pounds of Wettable Powder per 100 Gallons)	Number of Applications	Schedule	Drops April 15 to May 5		Number of First-Brood Adults per Tree Following Treatment	Per Cent of Infested Fruit at Harvest
			Total Number	Per Cent Infested		
Parathion (15%) 2	5	A	105	1.0	0.19	1.2
	4	B	139	7.2	0.06	0.4
Malathion (25%) 2	5	A	123	9.8	0.06	0.8
Dieldrin (50%) ½ Parathion (15%) 2	3 2	C	122	1.6	0.06	0
Lead arsenate 2	4	D	320	30.6	0.38	9.1

Table 3.—Comparison of dilute and concentrated parathion sprays for plum curculio control, 1954.

Type of Spray	Pounds of 15% Parathion per 100 Gallons	Gallons of Spray per Tree	Drops April 19 to May 3		Per Cent of Infested Fruit at Harvest
			Total Number	Per Cent Infested	
Dilute	2	1.0–1.3	105	1.0	1.2
Concentrated	4	0.5–0.7	184	10.3	2.5

Table 4.—Spray residues on fruit at harvest following treatment with various insecticides, 1954.

Insecticide (Pounds per 100 Gallons)	Schedule	Residue (p.p.m.)
Malathion (25% WP) 2	A	0
Dieldrin (50% WP) ½	C	0.25
1	C	.24
½	D	.14
1	D	.30
Aldrin (25% WP) 2	D	.11
Endrin (18.5% Em) 1 qt.	D	.27
Heptachlor (25% WP) 2	D	.29
CS-728 (25% WP) 2	D	.98

Table 5.—Effect of fresh deposits of insecticides on caged plum curculio adults, 1954.

Insecticide (Pounds of Wettable Powder per 100 Gallons)	Per Cent Mortality on Indicated Day of Exposure					
	Overwintering Brood				First Brood	
	1 Day	2 Days	3 Days	5–6 Days	2 Days	5–7 Days
Strobane (50%) 1	—	—	—	—	—	—
2[a]	70	90	100	—	—	—
3	—	—	—	—	—	100
Chlorthion (25%) 1	—	—	—	—	—	100
2	80	100	—	—	60	100
4	—	—	—	—	100	—
Perthane (50%) 2						
Alone	0	20	40	90	—	—
With Darvan No. 2[b]						
(1%) 4	—	—	—	—	—	100
(2%) 2	—	—	—	—	—	100
Parathion (15%) 2						
Alone	40	100	—	—	80	100
Plus hydrated lime 8	91	—	—	—	80	100
Methyl parathion (36%) 1	—	80	—	100	—	—
Check (untreated)	0	0	0	0	0	0

[a] 20 per cent mortality of the first brood after 34 days.
[b] A dispersing agent, product of R. T. Vanderbilt Company.

cage tests was determined by exposing curculios to their deposits at intervals after application. The residual value of Chlorthion and Strobane was rather poor but that of Perthane, with or without a dispersing agent, was fairly good against new first-brood adults. Lime did not affect the residual value of parathion against either overwintered or new first-brood adults. Parathion that had been on the tree 7 days killed all the new first-brood adults within 5 days, whether it was used alone or with hydrated lime.

The flavor of fresh ripe peaches was not affected, and no injury to the fruit, foliage, or any other part of the trees was discerned from any of the organic insecticides used as dilute sprays in either the field experiments or the cage tests, except that in the cage tests Chlorthion and Strobane caused some yellowing of the leaves, with some shot-holing and defoliation. However, the parathion 2X concentrate applied with a mist blower in a five-application schedule caused yellowing of the leaves and moderate defoliation by October 7. Lead arsenate, as used with zinc sulfate and hydrated lime in a four-application schedule, injured about 3 per cent of the peaches harvested from the trees to which it was applied. This treatment also caused moderate foliage injury and defoliation by October 7 even though dry-weather conditions prevailed during 1954.

PEACH TREE BORER.—Experiments were continued for control of the peach tree borer in orchard trees and for prevention of infestation in peach nursery stock. Three insecticides in wettable powder sprays applied to the trunks four times at 4-week intervals in 1953 were compared with two fumigant-type emulsions applied to the soil at the base of the trees. Each treatment was tested on five-tree plots of different ages replicated five times in a randomized setup in each of four orchards. The sprays were applied on July 30 or 31, August 27, September 29 or 30, and October 22, and the fumigant-type emulsions on October 26. The treatments used and the results obtained are given in table 6.

It is concluded from these experiments and previous experience that BHC and DDT are superior to parathion for use in trunk sprays, but that trunk sprays will not afford adequate protection from the peach tree borer in heavily infested orchards where there is a long oviposition period of the moths. Such sprays may prevent a buildup in the infestation and may afford adequate protection provided they are applied annually beginnning the first summer after the trees are set out. Ethylene dichloride and trichlorobenzene emulsions give excellent control of the peach tree borer in both nonbearing and bearing peach orchards, irrespective of the degree of infestation. Ethylene dichloride caused no tree injury at the dosage used, but trichlorobenzene caused some injury to most of the 2-year-old trees. It caused no injury to the older trees. More work with trichlorobenzene emulsion will have to be undertaken before it can be recommended for control of this borer.

Treatments of nursery stock to prevent infestation by the peach tree borer were compared in a block of June-budded trees in their second season of growth. The treatments were the same as the trunk sprays in the orchards, and they were made on the same dates. When the stock was examined on January 15–28, 1954, DDT was found

Table 6.—Results of experiments to control the peach tree borer.[a]

Insecticide	Pounds of WP or Pints of EM 100 Gallons or Pints per Tree	Age of Trees (Years)	Number of Live Borers per Tree
Wettable Powder Sprays Applied to Trunks			
BHC (10% gamma)	4.8	2	0
		3	1
		4	0.5
		6	0
DDT (75%)	5.3	2	0.04
		3	1
		4	0.5
		6	0
Parathion (15%)	2	2	0.04
		3	2.2
		4	0.9
		6	0
Emulsions Applied to Soil Around Trunks			
Ethylene dichloride 15%	0.25	2	0
	.5	3	0
20%	.5	4	0.1
		6	0
Trichlorobenzene (1.5%)	.25	2	0
		3	0.4
	.5	4	0
		6	0
Check (untreated)		2	0.6
		3	6.8
		4	4.9
		6	0.2

[a] Applications made in 1953, counts made April 27 to May 3, 1954.

to be somewhat more effective than BHC and still more effective than parathion, the respective percentages infested with the peach tree borer being 4.2, 7.6, and 13.3, as compared with 37.8 where no treatment had been used.

LESSER PEACH TREE BORER.—Areas of peach trees infested with the lesser peach tree borer were sprayed with 3 pounds of 25 per cent malathion, 2 pounds of 25 per cent EPN, or 3 pounds of 15 per cent parathion per 100 gallons on April 2, May 1, August 14, and September 8, 1953. The respective numbers of live borers per area on February 26, 1954, were 0.31, 0.13, and 0.09, as compared with 1.52 where no treatment had been applied.

It is concluded that, at the strengths at which they were compared, parathion and EPN are more effective than malathion for preventing infestation of peach trees by the lesser peach tree borer. In the latitude of Fort Valley, Georgia, it is believed applications are needed in early April and early May against the spring brood and in the latter part of August and the latter part of September against the fall brood.

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The Excretion of a Radioactive Metabolite by House Flies Treated with Carbon^{14} Labeled DDT[1]

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The metabolic fate of DDT when applied to house flies has been the object of the research of several investigators. It has become generally agreed that the primary degradation product of DDT is DDE (bis (p-chlorophenyl) dichloroethylene), an observation first made by Sternburg *et al.* (1950) and shortly later by Perry & Hoskins (1950). These investigators were unable to account for all of the dose applied in terms of DDT and DDE and suggested that other metabolites, not responding to the analytical techniques used, were also being formed. Perry & Hoskins (1951), for example, in analyzing surviving resistant flies 5 days after treatment were able to account for only 39 per cent of the original topically applied dose. Later, Tahori & Hoskins (1953), and Babers & Pratt (1953), obtained evidence that both susceptible and resistant flies produced an unknown metabolite in the degradation of DDT. All of these workers used the poor recovery of applied dosage as evidence that new metabolites of DDT were being produced.

It was the purpose of this study, using radioactive DDT, to further investigate the fate of this insecticide when applied to resistant and susceptible flies. The observations of previous authors concerning the production of a metabolite other than DDE have been confirmed. It has been found that this material is excreted, apparently in a water soluble conjugated form, in sufficient amounts to account for all of the applied dose. Attempts to identify this metabolite have failed.

METHODS AND MATERIALS.—The house flies used in these experiments were the Orlando No. 1 resistant strain, 147th to 160th generation, and a local non-resistant strain which has an LD_{50} for DDT, topically applied, of approximately 0.3 microgram per fly. No attempts were made to maintain the level of resistance of the

[1] Technical Paper No. 907, Oregon Agricultural Experiment Station. This investigation was supported in part by the Research and Development Division, Office of the Surgeon General, Department of the Army, under contract No. DA 49-007-MD-426. Accepted for publication May 6, 1955.

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Table 1.—The distribution of radioactivity in surviving female house flies at various intervals after treatment with radioactive DDT.

Experiment Number	Strain of Flies[a]	Dosage per Fly, c.p.m.[b]	Time Elapsed, Days	Activity, Per Cent of Original Dose				Total Recovery, Per Cent
				Flies		Excrement		
				Surface Rinse	Interior Extract	CCl_4 Soluble	H_2O Soluble	
15	Resistant	1050	12	2	53	8	20	83
16A	Susceptible	113	8	6	24	14	58	102
16B	Resistant	97	8	2	40	8	63	113
17	Resistant	1200	11	4	70	6	14	94
18	Resistant	500	5	1	42	6	20	69
19	Resistant	435	3	1	48	17	24	90
21	Resistant	644	14	5	47	11	35	98
22	Resistant	715	12	6	52	12	31	101
23	Susceptible	50	13	0	4	11	88	103

[a] At least 100 flies were used in each experiment.
[b] For approximate dose in micrograms, divide by 400.

Orlando strain which had a topical LD_{50} of about 100 micrograms per fly in the 147th generation.

The radioactive DDT used, m.p. 104–104.5° C., was tertiary carbon-labeled with specific activity of 1.49×10^8 counts per minute (c.p.m.) per millimole (approximately 400 c.p.m./microgram) and was synthesized by the method of Buhler *et al.* (1953). It contained no water soluble material and gave the characteristic DDT reaction with the Schechter-Haller test.

The flies were treated on the thorax with a $\frac{1}{4}$ ml. micrometer-driven syringe. Only female flies were used in the experiments. One microliter of an acetone solution of DDT was applied per fly. To determine the dosage in c.p.m. per fly, treated flies were set aside periodically during the treatment and killed immediately. The extraction of these flies and the determination of the radioactivity of the extracts were performed in the same manner as those examined later in the experiment. Thus all of the fractions of an experiment were subjected to the same counting errors, permitting them to be compared and totalled for recovery data.

The treated flies were held at 29° C. in 1- or 2-quart fruit jars with wire screen tops and were fed sugar and water. The experiments were from 3 to 14 days duration. In preliminary experiments it was discovered that appreciable quantities of a radioactive water soluble material were present in the excrement of treated flies. Subsequent experiments were then designed to determine the amount of this material produced by the surviving flies. This was done by transferring the survivors to a fresh jar periodically as determined by the mortality. Since the heaviest mortality occurred during the first 24 hours, the first transfer was made at this time. The survivors were kept in the new jar as long as the mortality was low, or until several days had passed. With this arrangement it was possible to determine the average amount of radioactivity excreted per fly.

Preliminary experiments indicated that all of the radioactivity applied to the flies could be accounted for in four fractions; a carbon tetrachloride (CCl_4) surface rinse of the flies, a n-hexane extract of the tissue, a CCl_4 extract of the excrement, and an aqueous extract of the excrement. Standardized procedures were developed for obtaining these four radioactive fractions. The surface rinse fraction was obtained by three quick rinses with CCl_4. The tissue was extracted in a soxhlet apparatus after the tissue had been surface rinsed, dried, and ground with anhydrous sodium sulfate. The extraction was continued until a check of the radioactivity of the extract showed that a constant value had been reached.

The radioactivity remaining in the jars after a transfer of flies included that mechanically lost from the body surface of the flies as well as that excreted. To remove any DDT, DDE, or other fat soluble materials, the jars were thoroughly rinsed with CCl_4. Earlier experiments in which a series of such rinses were counted individually indicated that two rinses were sufficient to remove these materials.

A thorough scrubbing of the containers with small portions of water completed the recovery of the radioactivity. Because of the tenacity of the fly specks, a rubber policeman was required in this operation but the radioactivity extracted appeared to be truly water soluble. These extractions were continued until the containers were shown to be essentially free of radioactivity as indicated by a laboratory monitor. This seldom required more than 3 extractions of approximately 10 ml. each.

In recognition of the importance of the counting technique in working with tracers, much attention was given to the standardization of counting errors. Most of the samples were of sufficient activity to make it practical to seek a counting accuracy of 5 per cent. Duplicate planchets were prepared in all cases. All radioactivity measurements were made by the direct plating method.

RESULTS AND DISCUSSION.—In table 1 is shown the distribution of radioactivity in the four fractions already described. The data are shown on a per fly basis. It can be seen that with the exception of experiment 18 the recoveries of applied dosages are good.

The data in table 1 indicate that the percentage of water soluble metabolite produced depends on the amount of DDT applied as well as the time available for its production. In experiments 16a and 16b both resistant and susceptible flies, when given small doses, convert a greater proportion of it to excretion products. Experiment 23 indicates that eventually all of the absorbed dose is metabolized and excreted by the surviving fly.

It is to be expected that part of a topically applied insecticide will be lost mechanically as the newly treated fly recovers from its anesthesia and goes through the various stages of DDT intoxication. It is seen in table 1 that up to 17 per cent of the applied dose is recovered as a CCl_4 soluble excrement fraction. Since the containers were changed several times during the eexperiments and the radioactivity present on the body surface of the fly soon reached a low level, it seemed unlikely that much of this CCl_4 soluble activity would be DDT. Schechter-Haller analyses confirmed this opinion showing that the majority of the radioactivity in this fraction was DDE.

A further breakdown on the excretion of the water soluble material is given in table 2. In most cases a larger percentage was excreted during the first 24 hours than during succeeding days. The exception to this is experiment 19. In spite of the heavier excretion during the first day, however, the amount of the applied dose accounted for during this critical period seems too small to account for the fly's survival.

The Nature of the Unknown Metabolite.—Much evidence was obtained which indicated that the excreted water soluble material was hydrolyzable with acid to produce a material insoluble in water. For example in one typical experiment the aqueous fraction obtained during the first 24 hours contained 9000 c.p.m. Three extractions of this solution with 10 ml. portions of CCl_4 removed a total of 721 c.p.m. 7.7 per cent of the original activity, the last extraction being almost negative. After making the solution 2N with respect to hydrochloric acid, three extractions with CCl_4 removed an additional 10 per cent of the activity. When the solution was then refluxed 4 hours and extracted, 4800 c.p.m., or 53 per cent of the original activity, was removed from the aqueous phase.

The loss of water solubility when the radioactive excretion product is refluxed with acid suggests that the hydrolysis product is acidic in nature. Further evidence of this is shown by the fact that the radioactivity transferred to the organic phase after hydrolysis is extractable by dilute sodium hydroxide and to a lesser extent by sodium bicarbonate. Acidification of the basic aqueous phase then renders the metabolite soluble once again in CCl_4. The transfer of radioactivity from CCl_4 to the alkaline aqueous solution is not rapid, several extractions being required to extract up to 90 per cent of the activity. This might suggest that the unknown hydrolysis product is phenolic rather than carboxylic in nature.

Attempts to identify the hydrolyzed metabolite by means of paper chromatographic techniques were based on its acidic nature. Its migration characteristics were compared to several known compounds which were considered to be possible degradation products of DDT. The chromatographic system described by Fewster (1951) was used. A definite R_f value for the unknown could not be established in spite of several purifications by eluting and rechromatographing. The values obtained ranged from 0.65 to 0.9 with the most frequent value being 0.80 to 0.85. This served to eliminate benzoic, p-chlorobenzoic, p-hydroxybenzoic, and diphenylacetic acids, bis(p-hydroxyphenyl)-methane and 4,4′-dihydroxy benzophenone, all of which have R_f values below 0.6 or above 0.9 in this system. The DDT metabolite, bis(p-chlorophenyl) acetic acid (DDA), gave an R_f value of 0.8 and was therefore suspected as the unknown. The isotopic dilution method failed to confirm this, however. Paper electrophoresis was also used and it was found that all of the compounds mentioned above migrated in a basic buffer while the hydrolyzed unknown failed to move under the applied current. The only compound considered to be a likely metabolite which was not eliminated by the techniques mentioned was 4,4′-dichloro benzophenone. However, the stability of this compound to the Schechter-Haller colorimetric reaction seemed to eliminate it from consideration since the unknown hydrolysis product was destroyed by this test.

The unknown excretion product was tested in other ways for further characterization. Toxicity studies employing mosquito larvae revealed that the conjugated unknown was completely non-toxic when compared to DDT. Attempts to hydrolyze the conjugate with the enzymes emulsin and beta-glucuronidase failed, indicating that the conjugate was neither a glucoside nor a glucuronide.

The data in table 1 indicate that both susceptible and resistant flies possess a mechanism for detoxifying DDT and excreting the products. Because of the difference in tolerated doses it is difficult to determine whether resistant flies have a greater capacity to achieve this metabolism. However, a comparison of two such strains at sublethal dosages indicates that there is no difference. Again the data in table 2 can be interpreted to show that there is a limit to the amount of DDT metabolized by this process and that this limit is not appreciably above the rate found with susceptible flies. Thus in comparing experiments 16a and 16b with experiment 22 it is seen that increasing the dosage by a factor of 7 results in an increase in the average daily excretion of the unknown by a factor of only 2.4. It appears, then, that the two strains do not differ greatly in this respect.

The rate of excretion of the detoxification products shown in table 2 suggests that this excretion is not vital to the survival of the fly except in whatever influence it

Table 2.—The excretion of a water soluble metabolite by DDT-treated female house flies.

Experiment Number	Strain of Flies	Dosage per Fly, c.p.m.[a]	Time Interval, Days	Water Soluble Activity		Total, Per Cent
				c.p.m. per Fly	Per Cent of Original Dose	
16a	Susceptible	113	0–8	66	58	58
16b	Resistant	97	0–8	61	63	63
18	Resistant	500	0–1	37	7.3	
			1–2	18	3.7	
			2–4	30	6.0	
			4–5	14	2.7	19.7
19	Resistant	435	0–1	35	8.1	
			1–3	70	16.1	24.2
21	Resistant	644	0–1	39	6.1	
			1–7	80	12.4	
			7–14	109	16.9	35.4
22	Resistant	715	0–1	35	4.9	
			1–8	120	16.8	
			8–12	69	9.7	31.4
23	Susceptible	50	0–1	4	8.0	
			1–7	13	26.0	
			7–13	27	54.0	88.0

[a] For approximate dose in micrograms, divide by 400.

may have on the conversion of DDT to DDE. Other workers have shown that the majority of the absorbed DDT is converted to DDE within 2 days by surviving flies, (Perry & Hoskins 1951, and Babers & Pratt 1953). The current data, therefore, which show that the excretion process proceeds for at least 2 weeks, must indicate that this process has very little influence on the production of DDE. It must therefore be considered a secondary detoxification process, at least in the case of resistant flies, which follows normal physiological routes.

It is interesting to consider the possible structure of the radioactive excretion product. Although DDA and p-chlorobenzoic acid had already been eliminated as possible metabolites by Sternburg & Kearns (1952) it was thought that in view of the water soluble nature of the conjugate they might have been overlooked by these and other authors. However, experiments with paper chromatography and other techniques served only to confirm the results of the previous investigators. In considering the instability of the radioactive hydrolysis product to the Schechter-Haller test and its apparently weak acidic nature, it appears possible that this material might be a phenol. Azouz *et al.* (1953) have shown that rabbits metabolize chlorobenzene to 4-chlorocatechol and to a smaller extent, p-chlorophenol. These phenols are excreted as various conjugates. Azouz cites the formation of heptachlor epoxide (Davidow & Radomski 1953) as precedence for a possible mechanism for the formation of such phenols. The conversion of aromatic compounds to phenols followed by conjugation and excretion is an intriguing possibility because it would provide an explanation for the resistance of house flies to other chlorinated hydrocarbons, a phenomenon which has remained unexplained during the efforts to elucidate the mechanism of DDT resistance.

SUMMARY.—Resistant and susceptible house flies have been examined for evidence of metabolism of DDT up to 14 days after treatment with radioactive DDT. Susceptible flies, given sublethal doses, have been shown to excrete up to 88 per cent of the dose in the form of a water soluble conjugate. Resistant flies show a similar detoxification and excretion capacity. The excretion begins during the first day after treatment and appears to continue until all of the absorbed dose has been metabolized.

The conjugate is hydrolyzable with acid to produce a compound weakly acidic in nature. Attempts to identify this compound have met with no success although several possible structures have been eliminated.

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Light-Trap Investigations at Stoneville, Miss., and Tallulah, La., During 1954[1]

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It has been established that insect traps utilizing light energy in the near-ultraviolet portion of the spectrum are attractive to adults of the pink bollworm (*Pectinophora gossypiella* (Saund.) and certain other insects. These traps are being used at selected locations in the Cotton Belt for survey purposes. At Stoneville, Miss., and Tallulah, La., such traps were installed in March 1953 for the primary purpose of detecting the presence of the pink bollworm when and if it reached the Mississippi Delta. During examination of the catches for pink bollworm moths various other economic species of Lepidoptera were recorded, and this paper is a preliminary report on these collections.

Other workers have investigated lights for trapping insects. Gui *et al.* (1942) found that lights of various colors attracted insects, and that blue light was the most effective, followed in order by white, yellow, and red.

Frost (1952) studied types of light traps used from 1886 to 1950, and concluded that the earlier traps were not successful because suitable lamps were not available. Burkes *et al.* (1938) reported that the mercury-vapor light offered many advantages over other lights for use in attracting nocturnal insects. They found this light rich in those frequencies in the short wave-length end of the visible spectrum, to which most insects respond readily, being far supperior to neon in this respect.

Martin & Houser (1941) reported that *Heliothis armigera* (Hbn.) and *Pseudaletia* (=*Cirphis*) *unipuncta* (Haw.) showed no sharp preference for any of a series of lights ranging in brightness from 2300 to 65,000 lumens with the exception of a 150-watt tungsten Mazda light. No more *armigera* moths came to the light with ultraviolet rays than to one of equal intensity and about the same spectral quality but without ultraviolet. Frost (1953) reported that Microlepidoptera were more strongly attracted to black light than to white light but the Macrolepidoptera were about equally attracted to both lights. He found that on a foot-candle basis the black light was far more attractive to insects. Glick & Hollingsworth (1954) reported that in general the black-light traps were more effective than the mercury-vapor lamps in attracting the pink bollworm moth.

Both black-light and mercury-vapor traps were used at Tallulah, but only a mercury-vapor trap at Stoneville. The black-light trap used a 15-watt black-light fluorescent lamp mounted vertically in the center of the trap, and the light was visible throughout a full 360° in the horizontal plane. The mercury-vapor trap was equipped with a 100-watt lamp of the spot type that casts a narrow, concentrated beam of bluish-white light in the visible region of the spectrum. The perceptible illumination covered approximately 2 acres. Both traps were controlled by time clocks adjusted to turn them on and off at dusk and dawn. Calcium cyanide was utilized to kill the insects as they were trapped.

The catches in the trap at Stoneville are shown in table 1, and those at Tallulah in table 2. The use of two types of traps at Tallulah afforded a good opportunity for comparing their effectiveness in catching moths.

It was interesting to note that the two species of *Heliothis* responded similarly to the lights, being attracted slightly more to the black light. The two species of *Agrotis* were also more attracted to the black light. These examples show the type of reaction that might be expected of species within a given genus. However, the genus *Protoparce* reacted quite differently. Fifty-nine per cent of the *sexta* specimens were caught in the black-light trap and 71 per cent of *quinquemaculata* in the mercury-vapor trap.

These examples indicate that much more information is needed on the reaction of insects to light traps, since each species is a separate problem. One type of light could be highly effective in trapping one species but not other closely related species. Some moths, such as the armyworm and the black cutworm, were caught through-

Table 1.—Catches of various species of Lepidoptera in mercury-vapor light trap at Stoneville, Miss., January 1 to September 30, 1954.

Species	Date First Caught	Maximum Number Caught per Night	Date of Maximum Catch	Total Number Caught
Bollworm (*Heliothis armigera* (Hbn.))	Feb. 26	604	Aug. 22	15,827
Armyworm (*Pseudaletia unipuncta* (Haw.))	Jan. 4	1,047	May 26	13,736
Cutworms	Jan. 5	150	May 25	7,013
Cabbage looper (*Trichoplusia ni* (Hbn.))	Feb. 16	550	Aug. 7	5,136
Yellow-striped armyworm (*Prodenia ornithogalli* Guen.)	Jan. 20	102	Aug. 23	3,261
Sphinx miscellaneous	May 25	78	Aug. 24	2,784
Fall armyworm (*Laphygma frugiperda* (A. & S.)	June 1	247	Sept. 29	1,789
Tobacco budworm (*Heliothis virescens* (F.))	Apr. 16	78	Aug. 7	1,411
Cotton leafworm (*Alabama argillacea* (Hbn.))	Aug. 23	56	Sept. 30	425
Salt-marsh caterpillar (*Estigmene acrea* (Drury))	Mar. 23	11	Apr. 28	118

Table 2.—Catches of various species of Lepidoptera in mercury-vapor and black-light traps at Tallulah, La., June 1 to October 1, 1954.

Species	Mercury-Vapor Trap		Black-Light Trap	
	Number	Per Cent	Number	Per Cent
White-lined sphinx (*Celerio lineata* (F.))	136	80.5	33	19.5
Tomato hornworm (*Protoparce quinquemaculata* (Haw.))	32	71.1	13	28.9
Armyworm	2,407	50.9	2,416	49.1
Tobacco budworm	289	47.8	315	52.2
Bollworm	7,364	47.0	8,319	53.0
Cotton leafworm	76	43.2	100	56.8
Tobacco hornworm (*Protoparce sexta* (Johan.))	612	41.0	880	59.0
Laphygma spp.	1,055	30.5	2,402	69.5
Black cutworm (*Agrotis ypsilon* (Rott.))	108	28.6	269	71.4
Pale-sided cutworm (*Agrotis malefida* Guen.)	156	28.5	417	71.5
Salt-marsh caterpillar	19	26.4	53	73.6
Prodenia spp.	200	25.5	583	74.5
Granulate cutworm (*Feltia subterranea* (F.))	283	15.5	1,539	84.5

[1] Accepted for publication May 5, 1955. In cooperation with the Delta Branch of the Mississippi Agricultural Experiment Station.

out the year. The cotton leafworm and the fall armyworm were seasonal in their appearance.

There has been much interest in light-trap catches in the Mississippi Delta during the last 2 years. It is generally believed that damaging outbreaks, especially of the bollworm and the tobacco budworm, could be predicted several days or weeks in advance by checking of the number of moths trapped at a given time. A correlation analysis showed a highly significant relationship between the number of bollworm moths caught in light traps and the number of eggs per 100 terminals found in cotton fields during the summer months. At the 1 per cent level the coefficients were 0.801 and 0.826 at Stoneville and Tallulah, respectively, compared with 0.765 required for significance.

There has also been much discussion concerning the importance of the tobacco budworm in the "bollworm" complex. This light-trap study afforded an excellent opportunity for getting comparative figures on the numbers of tobacco budworms and bollworms. During July and August larvae were collected and sent to Washington for identification. Table 3 gives the figures for the two insects from April through September 1954. At Stoneville more than 92 per cent of the moths of these two species caught in the light trap were bollworms. However, of the larvae collected from cotton fields less than 70 per cent were bollworms. At Tallulah 96 per cent of the moths of these species caught in the traps and 83 per cent of the larvae taken in the fields were bollworms. In both localities the percentage of bollworm larvae collected in the fields was considerably lower than the catches of bollworm moths. Although bollworm moths are more readily trapped with light traps than tobacco budworm moths, the bollworm moths are attracted from crops other than cotton, whereas the tobacco budworm is largely restricted to cotton in this area. The relative percentages of the two species caught in the traps may therefore reflect closely the relative numbers in a given area.

Table 3.—Comparison of bollworm and tobacco budworm moths caught in light traps and larvae collected in fields at Stoneville, Miss., and Tallulah, La., 1954.

Month	Tallulah			Stoneville		
	Number of Bollworms	Number of Budworms	Per Cent of Bollworms	Number of Bollworms	Number of Budworms	Per Cent of Bollworms
	Moths Taken in Light Traps					
April	—	—	—	75	8	87.9
May	463	18	96.3	279	9	97.2
June	456	46	90.8	496	30	94.3
July	3,202	102	96.9	1,599	111	93.5
August	8,018	335	96.0	7,879	765	91.1
September	4,007	121	97.1	5,230	522	90.9
Total	16,146	622	—	15,558	1,445	—
Average	3,229	124	96.3	2,593	241	92.5
	Larvae Collected in Fields					
July	62	29	68.1	50	57	46.7
August	105	2	98.1	59	5	92.2
Total	167	31	—	109	62	—
Average	84	16	83.1	55	31	69.4

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New Mosquito Repellents[1]

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Some new insect repellents synthesized at the Beltsville, Md., laboratories of the Entomology Research Branch (Barthel *et al.* 1954, Leon *et al.* 1954, McCabe *et al.* 1954) were submitted to the Orlando, Fla., laboratory for testing against various insects. They were first tested as clothing treatments against *Aedes aegypti* (L.) by the standard screening procedure described by King (1954). Repellents that allowed less than five bites in a 1-minute exposure to caged mosquitoes after the treatments had aged more than 10 days were considered sufficiently promising for further study. On the basis of tests on rabbits at the Army Environmental Health Laboratory, Detachment No. 1, located at Orlando, 12 were deemed safe for restricted experimental use on human subjects. One of them, the allyl ester of mandelic acid, proved irritating when applied to human skin. Results of tests with the other 11 repellents against 4 genera of mosquitoes are presented in this paper.

METHODS AND MATERIALS.—Tests against *Aedes aegypti* and *Anopheles quadrimaculatus* Say were conducted in the laboratory, whereas those against the salt-marsh mosquitoes, *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Walkr.), and *Psorophora confinnis* (L.-Arr.) were conducted in the field. In all tests 1 ml. of repellent was spread evenly over the forearm of the subject, and compared directly with another repellent on the other arm. In the laboratory tests each arm was exposed for 3 minutes at approximately 30-minute intervals to caged *aegypti* or at 20-minute intervals to caged *quadrimaculatus*. In the field the treated arms were exposed continuously to natural infestations. Effectiveness was usually based on complete protection, that is, the time between treatment and the first confirmed bite (a bite followed by another within 30 minutes). In tests with

[1] Accepted for publication May 9, 1955. This work was conducted under funds allotted by the Department of the Army to the Entomology Research Branch.

[2] The writers acknowledge the assistance of W. C. McDuffie, under whose supervision this work was done, and also of Nelson Smith, S. R. Pratt, R. L. Fye, R. A. Sutton, John Pituch, C. E. Hitchcock, and H. R. Ford.

quadrimaculatus the per cent protection given by diluted repellents was computed from the biting rates on treated arms and the average rate on untreated arms at the beginning and end of the test period.

Some of the tests were run with full-strength chemicals and others at reduced concentrations, with ethanol as the diluent. Three experimental designs were employed. In paired tests the experimental repellent was compared directly with a standard repellent on opposite arms of the same subjects. In block tests the repellents were tested in blocks of five in comparison with the standard and each repellent was tested once on each of three or four subjects. In round-robin tests each repellent was paired against each other repellent on opposite arms of the same subjects. An adjusted average protection period, which adjusts for individual variation between hosts and testing conditions, was computed by the following formula:

$$\text{Average } Ti = \frac{2Ti - Bi}{rn} + M$$

where Ti is the total protection times for all tests with repellent i, Bi is the total protection time for both repellents in all pairs in which repellent i occurred, n is the number of repellents, r is the number of times each pair was replicated, and M is the grand mean of all protection times in the series.

The new repellents were compared with four standard repellents, two of which were mixtures. The relative effectiveness was expressed as the ratio of the protection time of the experimental repellent to that of a standard. The ratio is a more reliable index than the actual protection time, which varies greatly between different hosts and different populations of mosquitoes. The names of the individual repellents and the formulas of the mixtures are given below, together with the Orlando code number for each.

NEW REPELLENTS

20023	Citral-malonic acid, condensate No. 1
20034	3-Buten-1-ol, 1-(*o*-methoxyphenyl)-
20127	Mandelic acid, amyl ester
20188	Cyclohexanecarboxylic acid, 1-hydroxy-, 2-propoxyethyl ester
20217	*o*-Toluamide, *N,N*-diethyl-
20218	*m*-Toluamide, *N,N*-diethyl-
20219	*p*-Toluamide, *N,N*-diethyl-
20224	Mandelic acid, propyl ester
20293	Piperonyl alcohol, *alpha-tert*-butyl-
20297	Benzamide, *o*-ethoxy-*N,N*-diethyl-
20299	Benazmide, *o*-bromo-*N,N*-diethyl-

STANDARD REPELLENTS

262	Dimethyl phthalate
375	1,3-Hexanediol, 2-ethyl-
M-250	262 (60%), 375 (20%), Indalone (20%)
M-2020	262 (40%), 375 (30%), dimethyl carbate (30%)

LABORATORY TESTS AGAINST AEDES AEGYPTI.—Ten of the new repellents were compared with standard M-250 in paired tests against *Aedes aegypti*. The results obtained are presented in table 1. The outstanding repellent was 20218, with a ratio to M-250 of about 2.7. The ratios of 20217 and 20299 were near 2, and those of compounds 20127, 20188, 20224, and 20297 were near 1.5. The other three chemicals, 20023, 20034, and 20293, were about equal to the standard.

Table 1.—Relative effectiveness of 10 repellents in paired tests as skin applications against *Aedes aegypti*.[a]

Repellent No.	Minutes to First Bite: Experimental Repellent	Minutes to First Bite: Standard Repellent	Ratio to M-250
20023	176	179	0.98
20034	242	207	1.17
20127	258	169	1.53
20188	274	177	1.55
20217	356	183	1.95
20218	249	92	2.71
20224	277	176	1.57
20293	256	215	1.19
20297	306	190	1.61
20299	290	140	2.07

[a] Repellent M-250 used as standard. Three replications.

The eleventh compound, 20219, being a solid, was tested at concentration of 25 and 50 per cent in a round-robin series with other solid chemicals not included in this paper, with M-2020 at like concentrations as the standard. Results of 12 tests showed 20219 equal in effectiveness to M-2020 at 25 per cent concentration but less effective at 50 per cent. The protection periods for the respective solutions averaged 86 and 193 minutes for 20219, and 83 and 255 minutes for M-2020.

FIELD TESTS AGAINST SALT-MARSH MOSQUITOES.—Two series of tests were conducted against mixed populations of the two species of salt-marsh mosquitoes. In the first series seven of the compounds were used at full strength in paired tests with M-250 as the standard. The results are presented in table 2. In the second series three other compounds and M-2020 were compared at concentrations of 50 per cent by the round-robin design. The times to the first confirmed bite and the ratios with M-2020 are shown in table 3.

Of the seven repellents in the first series 20224 and 20023 were the most effective. Compounds 20293 and 20297 were slightly more effective than M-250, and 20034, 20127, and 20217 were about equal to M-250.

In the second series 20218 and 20299 were superior to M-2020, but 20188 was slightly less effective than M-2020, which is effective for longer periods than M-250 in most tests against this species.

Table 2.—Relative effectiveness of seven repellents in paired tests against salt-marsh mosquitoes.[a]

Repellent No.	Number of Tests	Minutes to First Bite: Experimental Repellent	Minutes to First Bite: Standard Repellent	Ratio to M-250
20023	3	120	85	1.41
20034	3	124	126	0.98
20127	2	86	80	1.08
20217	2	86	84	1.02
20224	3	119	68	1.75
20293	2	108	87	1.24
20297	3	115	100	1.15

[a] Repellent M-250 used as the standard.

Table 3.—Relative effectiveness of 50 per cent ethanol solutions of three experimental repellents and M-2020 in a round-robin series against salt-marsh mosquitoes.[a]

REPELLENT No.	MINUTES TO FIRST BITE	RATIO TO M-2020
M-2020	153	1.00
20188	127	0.83
20218	265	1.73
20299	205	1.34

[a] Average of 8 tests.

Although 20299 was slightly more effective than its close relative, 20297, it was dropped from further consideration because the probable additional cost of commercial production would not be justified.

FIELD TESTS AGAINST PSOROPHORA CONFINNIS.—Two series of round-robin tests against natural populations of *Psorophora confinnis* were conducted with 25 per cent solutions of eight experimental repellents in comparison with 375 as the standard. The results are presented in table 4.

Compound 20218 was the outstanding repellent against this mosquito. Compounds 20023, 20034, 20188, and 20297 were about equal to the standard, and 20127, 20224, and 20293 were less effective.

LABORATORY TESTS AGAINST ANOPHELES QUADRIMACULATUS.—Nine of the new repellents were compared at concentrations of 5 to 20 per cent with 262 in three series of tests against *quadrimaculatus*. A summary of the results is given in table 5.

Compound 20034 was slightly more effective than 262 at 5 per cent and equal at the two higher concentrations, 20218 was about equal to 262 at all concentrations, and 20217 was about equal in over-all effectiveness. The other repellents were less effective than 262 at two or all concentrations.

SUMMARY.—Eleven new repellents were tested against *Aedes aegypti* (L.), ten against *A. taeniorhynchus* (Wied.)

Table 4.—Relative effectiveness of 25 per cent solutions of eight repellents in round-robin tests against *Psorophora confinnis*.[a]

REPELLENT No.	MINUTES TO FIRST BITE	RATIO TO 375
	Series 1	
375	102	1.00
20023	95	0.93
20034	95	.93
20127	80	.78
20188	103	1.01
20224	84	.82
20293	66	.65
	Series 2	
375	94	1.00
20218	113	1.20
20297	86	.91

[a] Average of 12 tests.

Table 5.—Effectiveness of various concentrations of nine repellents against *Anopheles quadrimaculatus*.[a]

REPELLENT No.	5 PER CENT	7.5 PER CENT	10 PER CENT	20 PER CENT
		Series 1		
262	57.7	—	99.6	98.7
20034	75.6	—	99.1	99.0
20127	8.3	—	53.2	48.0
20188	44.7	—	82.8	88.4
20217	83.6	—	75.0	96.8
20224	73.9	—	55.3	92.4
		Series 2		
262	88.5	98.3	97.1	—
20023	91.2	91.6	81.3	—
20218	93.3	96.3	96.4	—
20293	76.1	75.8	73.1	—
		Series 3		
262	96.8	99.6	100.0	—
20297	66.7	76.0	93.6	—

[a] Per cent repellency during a 3-minute exposure based on the biting rate on untreated arms. Average of 3 or 4 tests.

and *sollicitans* (Wlkr.), eight against *Psorophora confinnis* (L.-Arr.), and nine against *Anopheles quadrimaculatus* Say.

The most consistently outstanding compound was *N,N*-diethyl-*m*-toluamide (20218), which was equal or superior to the standard repellent against each species. Its ortho isomer, 20217, was less effective against several species, but was equal or superior to the standard. *o*-Ethoxy-*N,N*-diethylbenzamide (20297) was equal or superior to the standard against all species except *quadrimaculatus*, but against most species somewhat less effective than 20218. Its *o*-bromo analog, 20299, was somewhat more effective against *taeniorhynchus-sollicitans* and *aegypti*, but was not tested against other species because it would be more costly to produce. A citral-malonic acid condensate (20023) was superior to the standard against *taeniorhynchus* and *sollicitans*, but equal to it against two other species and slightly less effective against *quadrimaculatus*. The propyl ester of mandelic acid (20224) was more effective than the standard against *aegypti* and *taeniorhynchus-sollicitans*, but less effective against the other two species.

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Reductions of Insecticidal Residue on Mature Green-Wrap Tomatoes[1]

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Residue reductions of insecticide sprays are important from the viewpoint of insect control and residue remaining on food material. These residues break down at varying rates, depending on the insecticide used, weather conditions and other factors. This presentation considers residues in connection with the proposed tolerance regulations given by Rockefeller (1954) who proposed residue tolerances of insecticidal residues on tomatoes of 7 p.p.m. for DDT and 1 p.p.m. for parathion.

Rates of reduction of malathion and parathion residues after aerosol application to greenhouse tomatoes were given by Smith *et al.* (1952). By plotting the time after treatment against p.p.m. residue data on semi-logarithmic graph paper, straight-line relationships were found. Similar relationships were found with parathion on apples, peaches and on Eureka lemons from data given by Barnes *et al.* (1950). Semi-logarithmic relationships were found by plotting the data given by Fahey *et al.* (1952) from applications of DDT, EPN and parathion on peaches and on apple foliage. Data on residue reductions of parathion from cherries by Johansen *et al.* (1954) were made linear by plotting the data on semi-logarithmic grids. The trends demonstrated from the above mentioned references are considered evidence for semi-logarithmic transformations to test the data at hand.

Methods.—Tomatoes used for the residue determinations were obtained from fie'd plots used for experiments on insect control and yields. Homestead was the variety used in the experiments. In accordance with Florida Station recommendations, fungicide sprays were applied with a power spray machine for control of late blight disease. Depending on plant size, from 3 to 11 nozzles per row were used, and from 75 to 190 gallons per acre of spray was applied each application. Zineb was applied at 5- or 7-day intervals for control of the late blight disease in 1952–53 and maneb in 1953–54. All insecticides were combined with the fungicide each year.

Insecticides were applied for reduction of serpentine leaf mines and worm injuries of fruits. Leaf mines were made by larvae of the *Liriomyza pusilla* "complex" and injuries of the fruit were made mostly by the tomato fruit worm, *Heliothis armigera* (Hbn.), although some were made by the fall armyworm, *Laphygma frugiperda* (J. E. Smith).

Nine applications of insecticides were made during the 1952–53 season, of which the last eight were made at weekly intervals; about 1700 gallons of insecticidal sprays were applied during this season. Eight applications of insecticidal sprays were applied in the 1953–54 season, all at weekly intervals, to total about 1400 gallons.

Although several insecticides were used each year, residue determinations were made on but a portion of them. The insecticides, dilutions, rates and the total pounds applied per acre for the season are listed in table 1 for those treatments used in residue determination.

Although temperature, rainfall, sunlight, and other factors undoubtedly affect weathering and loss of residue from tomato fruits there is not space nor time to present such evidence on these factors. The above mentioned factors were considered about usual for the area in which the tomatoes were grown.

Table 1.—Insecticides, dilutions, rates of application and total pounds applied per acre for the season. Homestead, Florida. 1952–1954.

Formulations	Year	Dilution per 100 Gallons	Total Pounds Technical Insecticide per Acre
DDT, 50% W.P.	1953	2 lbs.	12.6
DDT, 50% W.P. (combined with parathion as given below)	1954	1 lb.	7.3
Demeton, 2 lbs./gal. liquid	1953	1 pt.	3.3
Dilan, 25% W.P.	1953	5 lbs.	20.9
EPN, 27% W.P.	1952	0.5 lb.	1.6
	1953	0.5 lb.	4.2
	1954	0.5 lb.	2.8
Malathion, 25% W.P.	1953	4 lbs.	16.7
Parathion, 15% W.P.	1953	1 lb.	1.5
4 lbs./gal. liquid	1954	2 fl. oz.	0.7
Parathion, 4 lbs./gal. liquid		4 fl. oz.	1.5
Parathion, 4 lbs./gal. liquid		8 fl. oz.	2.9
Parathion, 15% W.P.	1954	1 lb.	2.0
Parathion, 4 lbs./gal. liquid (alternated with TDE below)	1954	0.33 pt.	2.3
Parathion, 15% W.P. combined with DDT as given above	1954	12 avoir. oz.	1.5
TDE 50% W.P. (alternated with parathion as given above)	1954	2 lbs.	7.3

Sampling and Residue Stripping Procedures.—A sample for residue determination consisted of 12 mature-green fruits from each treatment (including the check) picked with a minimum of handling to prevent loss of surface residues. The first sample of tomatoes in each case was picked between 3 and 4 hours (called 0.2 day) after the final insecticide application. Other samples were picked 2, 3, 6, 7 or 14 days later. These fruit were taken from the four randomized plots, from different plants, and from different parts (shaded and exposed) of plants.

Within an hour after picking the fruit, each sample was weighed and placed in a glass jar with a liter of solvent except as specified below. Each jar was covered tightly with cellophane and placed in a motor-driven shaker for 30 minutes. The fluid extract from each jar was placed in 2 pint jars which provided duplicate samples for analyses. Benzene (thiophene free) was used as the solvent for extraction of insecticidal residues, except for malathion in which case carbon tetrachloride was used.

[1] Florida Agricultural Experiment Station Journal Series, No. 382. Presented at the Annual Meeting of the Cotton States Branch of the Entomological Society of America held at Tampa, Florida, January 17–19, 1955. Accepted for publication May 5, 1955.

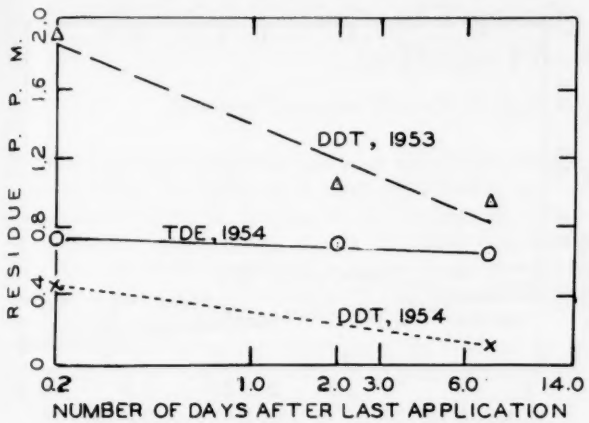

FIG. 1.—Rates of residue reduction of DDT W.P. alone and combined with parathion and TDE with alternation of parathion.

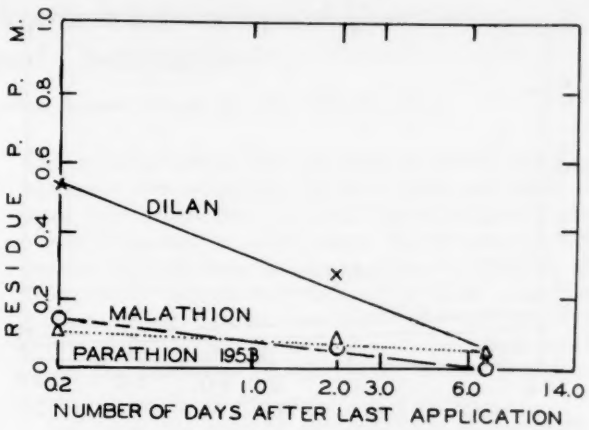

FIG. 3.—Rates of residue reduction of Dilan, malathion and parathion, 1953.

Samples from demeton-sprayed (and check) plants were picked at the times specified as above and sent for analyses immediately. Samples from demeton-sprayed and check plants were sent to Pittsburgh Coke and Chemical Company, Pittsburgh, Pennsylvania, via air express where they arrived 18 hours after picking. Samples sent to the junior author at Gainsville were sent via express or automobile and arrived a day or more after picking.

In 1952 samples from EPN-sprayed (and check) plants were sent via express to the E. I. duPont de Nemours and Company in Wilmington, Delaware, where they arrived a day after picking.

METHODS OF ANALYSIS.—The DDT and TDE samples were analyzed using the modification by Downing & Norton (1951) of the basic Schecter-Haller procedure. Parathion and EPN were analyzed using the method of Gunther & Blinn (1950). Malathion residues were determined by a procedure recently published by Norris *et al.* (1954). All of the above procedures are specific colorimetric methods. Demeton was determined by a modification of the enzymatic procedure recently proposed by Giang & Hall (1951) for the determination of organic phosphorous insecticides. This method is based on the property of some of these organic phosphates to inhibit the activity of the enzyme cholinesterase.

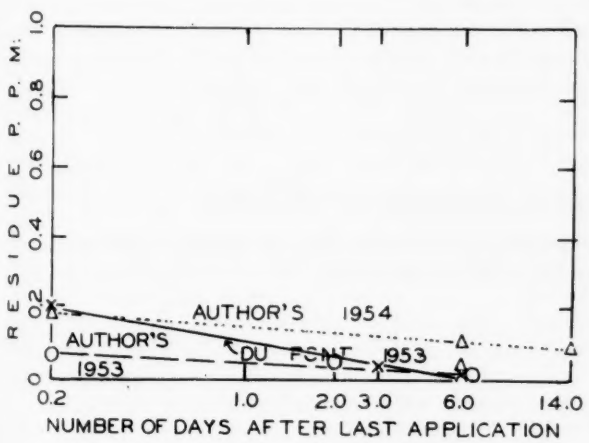

FIG. 2.—Rates of residue reduction of EPN.

RESULTS.—Results of the analyses are expressed in parts per million of fresh fruit. By plotting the results on semi-logarithmic paper, straight-line relationships were indicated. The independent variable, time in days after the last application, was therefore, converted to logarithms for computing the regression curves and making the comparisons. The method of least squares determination was used for deriving the regression equations.

Residue determinations of DDT were made in 1953 and 1954. More residue was found from the DDT treatments in 1953 than from any other treatment. Almost one-half of the residue found 0.2 day after the final application was lost within 7 days. In 1954 a low initial residue became much lower 14 days later (Fig. 1). Results of analyses of TDE-sprayed fruit are shown in Figure 1.

Residue determinations of EPN were made on samples of tomatoes sprayed in 1952, 1953 and 1954 with the results given in figure 2. Analyses in 1952 were made by the E. I. duPont de Nemours and Company; those in 1953 and 1954 were made by the authors.

Residue determinations of Dilan, malathion and parathion were made in 1953 and the results are given in figure 3. Dilan residues were greater than those of malathion or of parathion.

Residue determinations were made from different concentrations of a liquid parathion concentrate (4 lbs. per gal.) in 1954, the results are given in figure 4. Most residues were found on tomatoes sprayed with the highest concentration of parathion; least residues were found on fruit sprayed with the lowest concentration.

Residue determinations were made of parathion alone, parathion combined with DDT, and parathion alternated, with TDE, and the results are given in figure 5. In all instances low residues found 0.2 day after the last insecticide became even lower 6.0 and 14.0 days later.

All demeton residues showed 0.3 p.p.m. or less, and most samples showed none.

There is very close alignment of most observed and calculated values in figures 1, 2, 3, 4 and 5. This indicates that the sampling, analyses and residues were consistently uniform and that the errors were small.

FIG. 4.—Rates of residue reductions of different rates of parathion applications.

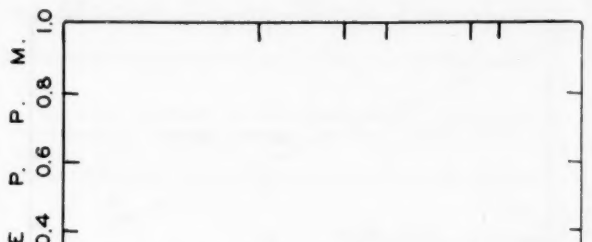

FIG. 5.—Rates of residue reductions of parathion W.P., parathion combined with DDT, and parathion with alternate applications of TDE.

CONCLUSIONS.—In all cases the residues were less than the proposed tolerance limits of DDT and parathion. The tolerance limits of Dilan, EPN, malathion and TDE have not been proposed for tomatoes. But since in this study only small amounts of residues of these insecticides, less than 1 p.p.m., were found it is likely that the residues on these green-wrap tomatoes would be within safe limits.

SUMMARY.—Residue analyses were made of tomato fruits which had been sprayed with DDT, demeton, Dilan, EPN, malathion, parathion and TDE. In all cases the residues were less than 2 p.p.m. at 0.2 day after the final spray application. At intervals of 2, 3, 6, 7 or 14 days after the last spray application successively less residues were found in all treatments. A semi-logarithmic relationship of p.p.m. residues and time after application was found.

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BULLETIN OF THE ENTOMOLOGICAL SOCIETY OF AMERICA

Members should read this publication carefully! It sometimes contains announcements, notices, etc., not sent to the membership in any other way.

Relative Toxicity of Topically Applied Allethrin and Pyrethrins to House Flies and Cockroaches[1]

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The insecticide allethrin has been the object of many studies since its synthesis in 1949 by Schecter and coworkers in the U. S. Bureau of Entomology and Plant Quarantine. March (1951) and Nash (1954) determined the amount of this insecticide per individual fly required to cause mortality, but as far as is known such data are available for no other insect.

In pursuance of an investigation of the mode of action of allethrin in this laboratory, it became necessary to determine the LD-50 in micrograms per cockroach and house fly. At the same time the relative toxicity of allethrin to that of the natural insecticide pyrethrins was determined by the method of topical application.

MATERIAL.—The allethrin was of a high degree of purity, analyzing 94 per cent by the hydrogenolysis method. The pyrethrins were obtained from a 42.8-mg./ml. stock solution in Deobase which has been prepared from pyrethrum flowers without the usual commercial purification processes; pyrethrin I and cinerin I comprised 60.5 per cent of the total pyrethrins when analyzed by the mercury-reduction method.

The American cockroach (*Periplaneta americana* (L.)), the German cockroach (*Blattella germanica* (L.)), and the house fly (*Musca domestica* L.) were the test insects.

PROCEDURE.—The insecticides were dissolved in acetone and diluted with the same solvent to form solutions containing the proper dosages as determined by preliminary tests.

The insects, under carbon dioxide anesthesia, were treated individually with 1.227 microliters of the acetone solution with the device described by Roan & Maeda (1953). Twenty-five cockroaches were used for each dosage except in the tests on American cockroaches with allethrin, when 50 were used. All American cockroaches were last-instar nymphs of approximately the same size; the German cockroaches were adult male insecticide-susceptible and -resistant strains (Heal *et al.* 1953). For each test with house flies 50 susceptible and 40 DDT-resistant females averaging 3 to 4 days of age were used. The susceptible flies were of the 1948 NAIDM strain, and the resistant flies of the Orlando-Beltsville strain that had been selected for DDT resistance for more than 150 generations. All tests against each strain were made on the same population except those with the American cockroach, which were duplicated against a second population. Mortality data for house flies were taken after 24 hours and for cockroaches after 120 hours.

To evaluate relative toxicity and determine the precision of the estimates, the mortality data were subjected to probit analysis as described by Finney (1952).[2]

RESULTS.—The mortality data are summarized in table 1. No knockdown observations were made, since the insects had been anesthetized to facilitate insecticide application.

Evaluation of Relative Toxicity.—The regression lines were fitted graphically to the data in table 1, and the provisional lines determined in order to ascertain relative toxicity in each series. The individual weighted regression equations were computed. Generalization was made in those series where the regression lines were found to be parallel upon analysis of chi-square. For all materials but one the data were found to be homogeneous; therefore, no heterogeneity factors were required for those materials. Analysis of the data for allethrin-treated resistant flies showed the chi-square for heterogeneity for pyrethrins to be on the borderline of significance. Hence a heterogeneity factor of 2.38 was used in this analysis.

The equations showing the regression of mortality, expressed in probits, on dosage, expressed as logarithms in micrograms per 100 insects, are as follows:

American cockroaches

Allethrin	$Y=1.561X+0.2547$
Pyrethrins	$Y=2.468X-0.4949$

Susceptible German cockroaches

Allethrin	$Y=2.183X+0.6783$
Pyrethrins	$Y=2.183X+3.7752$

Resistant German cockroaches

Allethrin	$Y=2.767X-0.6730$
Pyrethrins	$Y=1.119X+4.4126$

Susceptible house flies

Allethrin	$Y=4.815X-2.8120$
Pyrethrins	$Y=4.815X-3.2239$

Resistant house flies

Allethrin	$Y=6.663X-7.5015$
Pyrethrins	$Y=2.871X-0.5525$

From these equations the median lethal doses (LD-50's) were estimated and relative toxicities calculated as the inverse ratios of LD-50's, as given in table 2.

DISCUSSION.—It is well established that the relative toxicity of many insecticides varies with the species of insect. Allethrin and the pyrethrins proved to be no exception.

Whereas no deviation from parallelism could be demonstrated for the regression lines for susceptible house flies and German cockroaches, the tendency for the lines to converge was accentuated for the resistant insects. This proclivity has been noted before. Stoddard & Dove (1949) reported allethrin and pyrethrin lines to be nonparallel in tests on house flies using both the turntable and Peet-Grady methods. Gersdorff & Mitlin (1954), using the turntable method, stated that the slope for allethrin is usually demonstrably steeper. In an earlier study Gersdorff *et al.* (1951) declared that in some cases the difference in slope is so small that it is not statistically demonstrated in a reasonable number of tests. It must be remembered that both pyrethrins and allethrin, although treated as pure compounds, are mixtures. Allethrin, for example, is the *dl*-allethrolone ester of *dl*-cis, trans-chrysanthemumic acid and consists of eight optical

[1] Accepted for publication May 9, 1955.

[2] The authors gratefully acknowledge the advice and assistance of W. A. Gersdorff in the statistical phase of this investigation.

Table 1.—Mortality of cockroaches and house flies caused by allethrin and pyrethrins.[a]

Allethrin				Pyrethrins			
Susceptible Strain		Resistant Strain		Susceptible Strain		Resistant Strain	
Micrograms per Insect	Per Cent Mortality	Micrograms per Insect	Per Cent Mortality	Micrograms per Insect	Per Cent Mortality	Micrograms per Insect	Per Cent Mortality
American Cockroaches							
20	72	—	—	4.18	88	—	—
10	38	—	—	2.09	56	—	—
5	30	—	—	1.50	28	—	—
2.5	18	—	—	0.53	12	—	—
German Cockroaches							
5	96	2.5	92	0.209	88	0.209	84
1.25	60	1.25	48	0.053	72	0.105	68
0.625	32	0.625	16	0.027	44	0.053	56
0.312	12	0.312	12	—	—	0.027	48
House Flies							
1.0	94	1.6	95	1.0	96	1.6	82.5
.7	86	1.2	100	.7	74	1.2	67.5
.5	64	.9	67.5	.5	48	.9	32.5
.3	28	.675	32.5	.3	10	.675	42.5
		.507	12.5	—	—	.507	37.5
		.381	2.5	—	—	.381	10.0

[a] Mortality determined at 24 hours for house flies and 120 hours for cockroaches.

isomers. As pointed out by Finney, where the probit regression lines are not parallel the interpretation of comparative effects is more difficult. We have reported relative toxicity at the LD-50 level, and at other levels entirely different relationships will ensue.

The toxicity of allethrin did not differ significantly from that of pyrethrins at the LD-50 when tested against either susceptible or DDT-resistant house flies. This is not in agreement with March's (1951) results for susceptible flies, but does agree with his findings for the resistant Bellflower strain. March found allethrin to be 2.3 as toxic as pyrethrins to susceptible flies and approximately equal in toxicity to the Bellflower strain. In a third strain, the Pollard resistant strain, he found allethrin to be approximately 3.2 as effective as pyrethrins.

Neither do our results agree with those of Nash (1954). Although she used the same method of insecticide application, she found pyrethrins to be twice as toxic as allethrin at the median lethal dose. However, the sample of allethrin used in her study was of technical grade, assaying 80 per cent by an undescribed biological assay method, the insecticides were dissolved in an oil base, the ratios of the components of the pyrethrins mixture may have differed greatly from that of the sample used in this study and the criterion of mortality was different.

The results of the tests with German cockroaches confirm the conclusions of earlier investigators (Stoddard & Dove 1949, Moore 1950) that allethrin is less toxic than pyrethrins to this insect. This is true whether a resistant or a susceptible strain is used. Allethrin was found to be 0.03 as toxic as pyrethrins at the median dose.

Table 2.—Relative toxicity of allethrin and pyrethrins.

Insect	LD-50, Micrograms per Insect		Ratio of Toxicity, Allethrin/Pyrethrins
	Allethrin	Pyrethrins	
American cockroach	10.96 ±1.74	1.68 ±0.31	0.153±0.037
Susceptible German cockroach	0.954±0.016	0.036±0.007	0.036±0.009
Resistant German cockroach	1.123±0.150	0.033±0.007	0.029±0.007
Susceptible house fly	0.419±0.026	0.510±0.027	1.217±0.088
Resistant house fly	0.753±0.075	0.860±0.016	1.142±0.242

The synthetic material proved to be more effective when tested against the American cockroach. Although here again it did not approach the potency of pyrethrins, it was found to be 0.15 as toxic as that material when tested against last-instar nymphs.

SUMMARY.—The relative toxicity of allethrin and pyrethrins to susceptible and resistant female house flies (*Musca domestica* L.), susceptible and resistant adult male German cockroaches (*Blattella germanica* (L.)), and the last-instar nymph of the American cockroach (*Periplaneta americana* (L.)), was evaluated by the topical application method. Allethrin was found to be equally as toxic as pyrethrins to both strains of house flies, 0.03 as toxic to the susceptible and resistant German cockroaches, and 0.15 as toxic to last instar nymphs of the American cockroach.

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Acaricides in Insect Vector Virus Research[1]

H. R. WOLFE[2]

While rearing and maintaining leafhoppers and aphids for insect vector studies, the work is often hampered by infestations of certain spider mites. This has been a problem at the Tree Fruit Experiment Station, Wenatchee, Washington, for several years where research on insect vectors of fruit tree viruses is being conducted. Here, under greenhouse conditions, many stone fruit trees as well as annual plants, are utilized as either test plants or plants on which to rear insect vectors.

Spider mites, especially the two-spotted spider mite, *Tetranychus telarius* (L.), have built up rapidly on celery and peach seedlings in rearing cages. On plants where leafhoppers have laid eggs, such mite infestations have often killed the plants before the eggs have had time to hatch. When eggs hatch under such conditions, the newly-emerged nymphs must be transferred to healthy plants immediately if they are to survive long.

Heretofore it was considered that the only recourse was to start work with plants as free from mites as possible, and hope that the inevitable development of mite populations would occur late enough or in densities sparse enough to permit survival of the plants until completion of their use as rearing or test plants.

Most of the chemicals previously used to rid plants of mites in advance of using the plants in virus vector studies particularly the organic phosphates, had the disadvantages of residue retention and a toxicity to the vectors, even in the instance of TEPP which breaks down in a relatively short time. This stimulated the search for materials that are selective enough in their action to kill mites and not harm leafhoppers and aphids.

Sprays in greenhouses with wettable powders of Chlorobenzilate, 25 per cent at $1\frac{1}{2}$ pounds, Methyl Chlorobenzilate,[3] 25 per cent at $1\frac{1}{2}$ pounds, and Mitox,[4] 20 per cent at $2\frac{1}{2}$ pounds per 100 gallons gave good control of the two-spotted spider mite and prevented buildup of occasional light infestations of the European red spider mite, *Metatetranychus ulmi* (Koch). The purpose of this paper is to report on experiments demonstrating that the materials cause no apparent harm to leafhoppers or aphids and therefore are of especial value in virus vector research.

Chlorobenzilate sprays have been used successfully during the past 3 years for the control of mites in greenhouses where several species of leafhoppers and a few aphids have been maintained. This material has not only been used as a general spray throughout the greenhouse but also on individual plants just before they are used in insect vector virus tests. Such plants, when found infested with mites, were sprayed and used as soon as the plants were dry. Also by spraying plants used as hosts for rearing insects, mite infestations were kept to a minimum. These plants were thoroughly sprayed just prior to being caged. If mites began to build up on these plants at a later date, the cages and insects were removed, the plant sprayed again, and the cages and insects again placed on the plants. Although there apparently is no insecticidal effect on leafhoppers and aphids sprayed directly with the materials, this is avoided to prevent any damage to the insects which would be of a mechanical nature such as the insects' wings becoming stuck to wet portions of the cage or plant. This is usually not practiced where aphids are concerned, however, because of the difficulty in removing large colonies from rearing cages. Rapid multiplication of aphids usually overshadows any mite buildup. The greater need for mite suppression has been in leafhopper rearing cages where long periods of time are required for egg laying and development of nymphs.

Methyl Chlorobenzilate, although appearing slightly less phytotoxic, had no apparent other advantages over Chlorobenzilate. With both materials, sprays of $1\frac{1}{2}$ pounds 25 per cent W.P. per 100 gallons were usually required at 3-week intervals to check the general mite population. Emulsion forms were not used, thus avoiding any possible effects the solvents might have on insects.

Mitox has considerable acaricidal activity, mainly on the eggs and young stages of spider mites, with no known insecticidal effect to the eggs, immature stages or adults of any insect (Cranham *et al.* 1953). Two and one-half pounds 20 per cent W.P. per 100 gallons gave poor kill of *adult* spider mites in the greenhouse, therefore the material was limited to use in combination with Chlorobenzilate to prevent buildup of active mites.

Phytotoxicity tests were conducted to determine which concentrations of the acaricides could be used safely under greenhouse conditions. Chlorobenzilate and Methyl Chlorobenzilate at $1\frac{1}{2}$ pounds 25 per cent W.P. and Mitox at $2\frac{1}{2}$ pounds 20 per cent W.P. per 100 gallons did not cause injury to the following plants: peach, apricot, mazzard cherry, mahaleb cherry, montmorency cherry, chokecherry (*Prunus virginiana* var. *demissa* Nutt.), bitter cherry (*Prunus emarginata* Dougl.), Bessey cherry (*Prunus besseyi* Bailey), Manchu cherry (*Prunus tomentosa* Thunb.), apple seedlings, alfalfa, celery, aster, tobacco and jimson weed (*Datura stramonium* L.). *Physalis longifolia* Nutt. and *Physalis floridana* Tydberg were damaged slightly by the Mitox spray, however no burning on these plants resulted with Chlorobenzilate or Methyl Chlorobenzilate at the dosages mentioned above. Mitox caused severe burn on cucumber, as did Chlorobenzilate, however, Methyl Chlorobenzilate did not damage cucumber at the $1\frac{1}{2}$-pound dosage.

On celery, which is the plant most commonly used for rearing leafhoppers, at Wenatchee, Chlorobenzilate and Methyl Chlorobenzilate at 3 and 5 pounds caused no burning, and Mitox with dosages up to 5 pounds per 100 gallons caused no visible injury.

The geminate leafhopper, *Colladonus geminatus* (Van D.), the mountain leafhopper, *Colladonus montanus* (Van D.), the leafhoppers *Scaphytopius acutus* (Say),

[1] Accepted for publication May 20, 1955. Scientific Paper No. 1416. Washington Agricultural Experiment Stations, Project No. 848. This work represents cooperative efforts of the following agencies: The Washington State Department of Agriculture, the Washington Agricultural Experiment Stations and the United States Department of Agriculture, Entomology Research Branch.

[2] Assistant Entomologist, Tree Fruit Experiment Station, Wenatchee, Washington. The work from 1951 to 1953 was supported by the Washington State Department of Agriculture.

[3] methyl 4, 4′-dichlorobenzilate, supplied by the Geigy Company Inc.

[4] *p*-chlorobenzyl *p*-chlorophenyl sulfide, supplied by the Upjohn Company.

Gyponana hasta DeL., *Keonolla confluens* (Uhl.), *Fieberiella florii* (Stal), *Erythroneura dolosa* B.&G., *Erythroneura plena* Beam., *Dikraneura carneola* (Stal), *Exitianus exitiosus* (Uhl.), *Xerophloea viridis* (Fabricius), the six-spotted leafhopper, *Macrosteles fascifrons* (Stal), and the rose leafhopper, *Typhlocyba rosae* (L.), as well as the green peach aphid, *Myzus persicae* (Sulz.), the black cherry aphid, *Myzus cerasi* (F.), and the potato aphid, *Macrosiphum solanifolii* (Ashm.) have been exposed to these acaricides under greenhouse conditions without apparent harm.

Sprays of Chlorobenzilate and Methyl Chlorobenzilate at 1½ pounds 25 per cent W.P. and Mitox at 2½ pounds 20 per cent W.P. per 100 gallons did not appear to have any insecticidal effect on the green peach aphid, *M. persicae*. The insects fed and reproduced on treated plants, however they seemed to be disturbed by any spray deposit present, preferring to feed in an area where the deposit was at a minimum.

The geminate leafhopper, *C. geminatus*, has been maintained for experimental purposes in the greenhouse in greater numbers than any other insect. For this reason it was chosen to test effects of the acaricides on eggs, nymphs and adults of leafhoppers.

In this experiment, test plants were sprayed with dosages of 1, 1½ and 2 pounds Chlorobenzilate and Methyl Chlorobenzilate, and 2½, 3, 3½, and 4 pounds Mitox wettable powder formulations per 100 gallons of spray. Check plants were treated with water only.

A series of tests was conducted to determine the effect of the acaricides on the hatching of *C. geminatus* eggs. Eggs laid on test plants were counted prior to spray applications; some were ready to hatch and others were several days from hatching time. Twenty days following sprays at the various dosages, counts were made to determine the percentage of egg hatch. There was no significant difference ($p < 0.05$) in hatch between those on the treated plants and those treated with water. In another series of tests, leafhopper nymphs were caged on plants treated with the various dosages. A count of live leafhoppers after 45 days revealed no significant difference ($p < 0.05$) between the treatments and the checks. This was also true with adults, with the exception that in the Chlorobenzilate treatment there was a statistical difference ($p < 0.05$) which was small and of no practical consequence. Results of these tests are summarized in table 1.

Table 1.—Survival of eggs, nymphs, and adults of *Colladonus geminatus* on plants sprayed with acaricides. Wenatchee, Washington, 1954.

Materials Used	Dosages (Lbs. per 100 Gallons)	Percentage Egg Hatch on Peach 20 Days Following Application[a]	Percentage Surviving 45 Days on Celery[b]	
			Nymphs[c]	Adults[d]
Chlorobenzilate 25% W.P.	1	80.0	93.3	87.1
	1½	78.1	90.5	92.0
	2	80.1	91.5	84.1[e]
Water (Check)	0	80.0	93.6	90.0
Methyl Chlorobenzilate 25% W.P.	1	88.2	78.1	88.8
	1½	86.3	78.5	89.8
	2	82.6	76.1	89.0
Water (Check)	0	84.7	76.0	89.3
Mitox	2½	81.4	90.3	84.4
	3	79.7	86.3	85.0
	3½	79.4	89.1	78.0
	4	81.8	88.5	85.0
Water (Check)	0	79.9	90.1	84.5

[a] In four one-plant replications.
[b] In six one-plant replications.
[c] One hundred first-instar nymphs placed on each treated plant. All were adults at end of 45 days.
[d] One hundred leafhoppers, taken soon after reaching adult stage, placed on each treated plant.
[e] Significant difference ($P < 0.05$) from the check treatment. (L.S.D. = 5.7)

Summary.—The acaricides, Chlorobenzilate and Methyl Chlorobenzilate at 1½ pounds 25 per cent W.P. and Mitox at 2½ pounds 20 per cent W.P. per 100 gallons, caused no apparent harm to leafhoppers and aphids under greenhouse conditions where there is a need to control spider mites without harm to insects used in insect vector virus research.

Sprays up to 2 pounds with the Chlorobenzilates and up to 4 pounds per 100 gallons with Mitox had no appreciable effect on the survival of adults or nymphs of the geminate leafhopper, *Colladonus geminatus* (Van D.). Egg hatch was not significantly affected.

These materials, at the stated dosages, were not phytotoxic to most plants tested under greenhouse conditions.

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BOOK REVIEW

Crop Protection, by G. J. Rose, B.S.C., Entomologist, Micron Sprayers, Ltd. Cloth, xxi+323 pp., 113 half-tone figs. (9 in full color). Philosophical Library, Inc. 15 East 40th St., New York 16.

The introduction of Crop Protection gives as its purpose the integration of the achievements of the biologist, the chemist and the engineer for the benefit of the practical farmer. It is intended to show farmers and extension people the range of chemicals and machinery available and what sort of problems may be solved by their use.

However, the biological contributions are disposed of in eight pages and the rest of the book is devoted to pesticides and machinery. Two chapters are devoted to formulations. Weedkillers, insecticides, fungicides and rodenticides are listed in separate chapters. The listing of materials is reasonably complete. However, the chapter on combined formulations is very sketchy and the discussions of sulphur, pentachlorophenol and aerosols and smokes seems misplaced.

Dusters and sprayers are discussed briefly, although two types of sprayers are discussed under the heading of "other systems of application." There is an excellent short chapter on selection, operation and maintenance of equipment.

The book contains a summary of practical control measures, arranged by crop and pest, an appendix of information useful in spraying and dusting, and a comprehensive index.

The author has succeeded in presenting an adequate survey of the range of chemicals and types of machinery available to farmers. The survey of machinery seems far more adequate and complete than the discussion of pesticides. The summary of control measures is so brief that it appears to be a random sample of "recommendations" found in the literature. Many chapters are somewhat inadequate because of oversimplification, presumably necessary for brevity.

The list of illustrations of machinery is unusually complete and of good quality.

Neely Turner

SCIENTIFIC NOTES

Survival of Aphids After Injection[1]

KURT HEINZE,[2] *The Rockefeller Institute for Medical Research, New York, N. Y.*

In the course of studies of the fate of aphid-borne plant viruses in their respective vectors, attempts were made to introduce virus-containing fluids into full grown, wingless aphids. The small size of most species of aphid vectors, usually below 2 mm. in length, and the high outward pressure of the body fluids presented the main technical difficulties in aphid injections. The viruses chosen for the investigation were those of pea-enation-mosaic and potato-leafroll, both of which belong to the "persistent" type (Watson & Roberts 1939). It was not difficult to inject the American pea aphid, *Acyrthosiphon destructor* Johns, (=*Acyrtosiphon pisum* Harris *partim*) because full grown individuals of this species measure up to 4 mm. in length. After the technique was mastered, the much smaller peach aphid, *Myzus persicae* (Sulz.), was injected successfully.

Needles for insect injections were prepared from Pyrex glass tubing, first drawn out over a Bunsen burner flame and afterwards over a microburner, to obtain fine capillaries (Black 1941). These pipettes were slightly thinner at their tips than the tibia of an aphid. Sharp points were obtained by cutting the capillaries at angles of 45° with a razor blade. Short needles were found more rigid and therefore more suitable for use in making injections than long needles. Virus-containing inoculum was forced into the virus-free aphid by blowing into a rubber tube attached to the micropipette. During these operations the insects were kept under constant CO_2 anesthesia in a Büchner funnel mounted on the stage of a dissecting microscope (Maramorosch 1955). Ordinarily punctures were made into either side of an aphid with a pipette pointed towards the insect's posterior end. However, some punctures were made directly into the heart through the back in order to inoculate the blood. Pressure had to be maintained while the needle was being withdrawn to prevent the insect's blood from being forced back into the micropipette. Although severe wounds were often inflicted in the course of an injection, these soon healed and inoculated aphids continued to feed and to reproduce in a normal way. Usually up to 40 per cent of inoculated insects survived. Some lived as long as 4 weeks after the operation. Injected insects could be recognized easily because the healed wounds left pronounced marks. Figure 1 shows a pea aphid which reproduced in a normal manner after an inoculation wound had healed. Apparently no essential organs of the insect were permanently damaged since the rate of reproduction was retarded for only a few days following an injection.

In attempts to transmit pea-enation virus to aphids, both the sap of infected plants and the blood of infective vector aphids were used. Viruliferous aphids from which blood was to be secured were fastened to glass slides by means of droplets of water and potato starch. Bloodletting was accomplished by cutting off one or more legs with a sharp scissors. The survival of aphids inoculated with plant juices was much lower than that of aphids injected with blood. In addition to the injections made with micropipettes, punctures with insect pins previously dipped into virus-containing inoculum (Storey 1933) were tested. Despite numerous attempts made over a period of 10 months, no mechanical transmission of pea-enation-mosaic virus to its vector aphid was achieved. In tests described elsewhere (Heinze) similar attempts with potato-leafroll virus and the green peach aphid were successful.

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PAID PAPER.

[1] Accepted for publication September 22, 1955.

[2] Visiting Investigator, on a Fulbright Grant, on leave from the Biologische Bundesanstalt, Berlin-Dahlem, Germany.

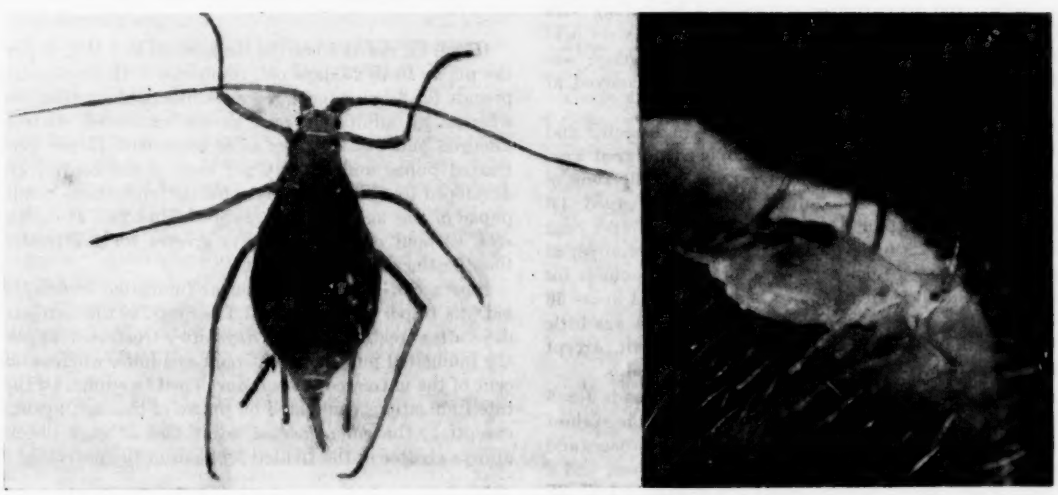

FIG. 1.—Two views of a very large healed wound of an American pea aphid (*Acyrthosiphon destructor* Johns.) 3 weeks after injection with blood from a viruliferous specimen. (Photograph by J. A. Carlile.)

Effect of Acrylonitrile Fumigation on Diapause in the Walnut Husk Fly[1]

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Diapause in insects is a spontaneous arrest of development which occurs irrespective of environmental conditions and is regarded as a means of surviving adverse conditions, notably the winter cold.

Boyce (1931, 1934) states that the diapause phenomenon is exceptionally well shown in the pupal stage of the walnut husk fly, *Rhagoletis completa* Cress. The larvae of this species feed on the husk tissue of walnuts, and when mature drop to the soil and pupate. Emergence as adults occurs either the following year, or 2 or more years after pupation. Boyce found an apparent effect of potassium thiocyanate and thiourea in shortening the diapause.

During the spring and summer of 1953 the authors were conducting experiments on the fumigation of walnut husk fly pupae to sterilize burlap sacks to prevent the spread of this insect to northern California. Fumigations were carried on both at atmospheric pressure and under vacuum, using hydrocyanic acid, methyl bromide, and acrylonitrile. Preliminary observations indicated that fumigation at atmospheric pressure with acrylonitrile had some effect on the breaking of diapause of this insect. In a fumigation conducted in November, 1953, using 2 pounds of acrylonitrile per 1000 cubic feet and an exposure of 4 hours at 70° F., 12 per cent of the fumigated pupae had emerged as adults by December 20, 1953, while in the untreated control no emergence took place until February, 1954, In the treated lot 41 per cent of the pupae had emerged by March, 1954, while only 6 per cent had emerged in the control. A series of experiments was planned the following season to test further the effect of acrylonitrile fumigation on diapause in the walnut husk fly.

In the fall of 1954, walnuts infested with husk fly larvae were collected and placed on soil to allow the mature larvae to leave the nuts and enter the soil to pupate. A large number of pupae (approximately 6000) were collected by sifting the soil, and they were stored at room temperature in a cloth-covered Mason jar. These pupae constituted the stock supply for the fumigation experiments. One hundred pupae were used in each fumigation, and the fumigations were conducted at intervals of approximately 3 weeks, starting October 1, 1954, and continuing to March 18, 1955. Various dosages of acrylonitrile and exposure times were used, at a temperature of 70° F. Forty fumigations were conducted, and an untreated control was held along with the samples fumigated on a given date. All samples were held at room temperature after fumigation. Adult emergence was checked biweekly, and all adult flies found were removed at each checking.

In late August, 1955, all remaining pupae were dissected and checked as to mortality. In the control sample 81 per cent were alive which included the number of live pupae at the time of dissection, plus the number of adults that had emerged. Of pupae fumigated at a 1-pound dosage for 2 hours 77 per cent were alive; at 2 pounds for 3 hours 79 per cent were alive; at 2.5 pounds for 3 hours 74 per cent were alive; at 3 pounds for 2 hours 77 per cent were alive; and at 3 pounds for 3 hours 56 per cent were alive. These figures indicate that there was little mortality from the acrylonitrile fumigation treatment, except at 3 pounds for 3 hours, where some mortality occurred.

The effects of acrylonitrile fumigation at 2.5 pounds for 3 hours and at 3 pounds for 3 hours on diapause in the walnut husk fly are given in table 1. Results were similar at dosages and exposures of 1 pound for 2 hours, 2 pounds for 3 hours, and 3 pounds for 2 hours, except that the effect at a dosage of 1 pound for 2 hours (the lowest dosage tested) was not so great as at the higher dosages and longer exposures.

Table 1.—Effect of acrylonitrile fumigation on diapause in the walnut husk fly.

Approximate Age of Pupae when Fumigated (Days)	Per Cent Adult Emergence (Fumigated / Control)				
	Days After Treatment				
	30–45	60	120	240	280
2.5-Lb. Dosage for 3 Hours					
10–25	8 / 0	10 / 0	12 / 2	47 / 16	57 / 27
30–45	7 / 0	7 / 0	12 / 3	42 / 22	57 / 32
52–67	9 / 0	9 / 0	19 / 9	46 / 22	
72–87	3 / 0	5 / 1	29 / 7	48 / 26	
93–108	16 / 1	43 / 6	52 / 12	64 / 36	
115–130	14 / 1	31 / 1	46 / 18	65 / 42	
3-Lb. Dosage for 3 Hours					
136–151	19 / 3	29 / 3	49 / 11	63 / 35	
158–173	3 / 0	52 / 10	59 / 23		
178–193	2 / 5	64 / 13	69 / 19		

It will be noted from the data in table 1 that 8 per cent of the pupae 10 to 25 days old, fumigated with acrylonitrile at 2.5 pounds for 3 hours, emerged as adults 38 days after treatment, whereas no adults emerged in the untreated controls. Two-hundred and twenty days after treatment 47 per cent of the treated pupae and only 16 per cent of the control group had developed to adults. Of three separate fumigations conducted on pupae of this age, the emergence of adult flies at each checking was, without exception, always greater for the treated pupae than for the untreated control.

Emergence of adults from pupae fumigated when 93–108 days old was 16 per cent as against 1 per cent in the untreated lot 30 days after treatment. Sixty days after treatment 43 per cent of the fumigated pupae had emerged as adults, whereas only 6 per cent of the untreated lot had developed to adults. Of three separate fumigations conducted on pupae of this age, again, with no exception, the emergence of adult flies at each checking was always greater in the treated lot than in the untreated controls.

PAID PAPER
[1] Accepted for publication October 10, 1955.

Emergence of adult flies from pupae fumigated when 178–193 days old was 2 per cent as against 5 per cent in the untreated control 38 days after treatment. Sixty days after treatment 64 per cent of the treated pupae had developed to adults, whereas only 13 per cent of the untreated controls had emerged as adults. Adult emergence increased to 69 per cent of the treated pupae as against 19 per cent in the untreated controls 120 days after fumigation. Of the three fumigations conducted on pupae 178–193 days old, the number of emerged adults 30 days after treatment was greater in some cases in the untreated controls, but in all later checkings the reverse occurred. Since some pupae at this age normally were developing to adults, it may be that the acrylonitrile fumigation had a temporary depressing effect on pupae ready to emerge as adults.

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Experimental Compounds for Control of Chlordane-Resistant German Cockroaches[1]

ERNEST W. LAAKE[2]

This report describes results of comparative field evaluation tests conducted cooperatively by the Savannah, Georgia Station of the Entomology Research Branch, Insects Affecting Man and Animals, Section, U.S.D.A. and the Orkin Exterminating Company, Inc., for the control of German cockroaches (*Blattella germanica* L). that have manifested a high degree of resistance to chlordane. Emulsions of the test materials were applied with a one-gallon B and G pressure sprayer equipped with a model 104-S Multeejet nozzle. Concentrations of 1.5% and 1% Chlorthion, mixtures of 1% Chlorthion and 1% dieldrin, mixtures of 2% malathion and 1% dieldrin, Compound AS-1590 containing 1.2% malathion and 2.4% Perthane, and Compound AS-1591 containing 1.6% malathion and 1.6% Strobane, and Malrin containing 1.8% malathion and 3.6% Perthane, all materials of technical grade, were applied to grocery and meat market establishments, Mexican food factories and residences in San Antonio, Texas.

Observations on the results obtained with the test materials were made at varying short intervals after application, but these observations had to be discontinued before the duration of residual effectiveness of each test material had ceased or could be fully determined.

The spray procedure followed in the tests in question was the best possible under the greatly varying conditions involved, but it was, with few exceptions, too incomplete with reference to uniform distribution and the extent of the infested area covered with the test materials to be considered adequate for elimination of the German cockroach with one treatment. This was especially true in the grocery stores where many shelves and portions of the aisles were blocked or stacked so high with food supplies that thorough treatment was utterly impossible. The tests, however, were entirely practical and the conditions were precisely as those pest control operators in the San Antonio, Texas area have to face every day.

Chlorthion was highly effective for the control of German cockroaches that were not affected by chlordane, but it was completely ineffective against the American cockroach. Mixtures of Chlorthion and dieldrin were effective against the German and the American cockroach and eliminated bed bugs with one treatment. Chlorthion, whether applied alone or in a mixture with dieldrin, was objectionable to the operators and definitely so to the personnel in treated buildings because of its odor which is irritating to most people upon exposure for an hour or more. Mixtures of malathion and dieldrin were effective against the resistant German cockroach and against the American and Oriental cockroaches in a tortilla factory and against German and American cockroaches in a residence. This mixture had no objectionable odor but the concentration of dieldrin applied may be considered a health hazard if it is freely used in residences or food stores. Malrin and Compounds AS-1590 and AS-1591 were effective in controlling the chlordane-resistant German cockroaches and the American cockroach. Malrin and Compounds AS-1590 and AS-1591 have no objectionable odor, were nice to handle by operators and were not irritating or offensive in any way to the occupants of treated buildings.

Based on the results of the tests described herein, Malrin appears as the safest material for controlling resistant German cockroaches. Mixtures of malathion and dieldrin appear most effective for controlling the resistant German, the American, and the Oriental cockroaches where these species are found together inhabiting household and industrial establishments.

PAID PAPER.
[1] Accepted for publication October 10, 1955.
[2] Entomologist, Public Health Department, City of Dallas, Texas. Formerly Entomology Research Branch, U. S. Dept. of Agriculture.

The Old House Borer in New York State[1]

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The establishment of the old house borer, *Hylotrupes bajulus* (L.), as a serious pest of wood structures in northeastern United States has been of growing concern to the writers. Although this insect is not encountered as frequently as other insects causing the deterioration of wood, such as the eastern subterranean termite, *Reticulitermes flavipes* Kollar, the powder post beetles of the families Anobiidae and Lyctidae, and the black carpenter ant, *Camponotus herculeanus pennsylvanicus* (DeG.), its attack in individual structures creates some of the most formidable control problems.

Since 1900, several collections of the old house borer have been made in New York State by various workers. Some of these are compiled by Leonard (1926). To these the writers wish to add some records which were kindly communicated to us by other workers and some which were brought to our attention by individual property owners. No effort was made to exhaust all possible sources of information, our purpose being to gain sufficient evidence of the widespread distribution of the old house borer throughout the state.

The localities of these collections are shown in figure 1. These, together with their source and other pertinent available data, are listed as follows:

M. D. Leonard (1926): Buffalo, Bronx, Moriches, Rockaway Beach, Staten Island, West Farms, Yonkers.

M. A. Cazier (American Museum of Natural History): Cold Spring Harbor (1900), Moriches (1909), New York City, Southampton, Staten Island.

D. L. Collins and D. P. Connola (N. Y. State Science Service): Hillsdale (larva, 1951); Ogdensburg (larva, 1951); Yonkers (adult, 1904).

W. B. Becker (University of Massachusetts; collected by D. H. Lewis): Medina (larva, 1950).

Collections by the writers: Auburn (adult, in Southern yellow pine *Pinus* spp., 1950); Binghamton (larva, in southern yellow pine *Pinus* spp. 1950); Buffalo (adult, 1954); Henderson Harbor (larvae, in southern yellow pine *Pinus* spp. and

[1] Accepted for publication April 18, 1955.

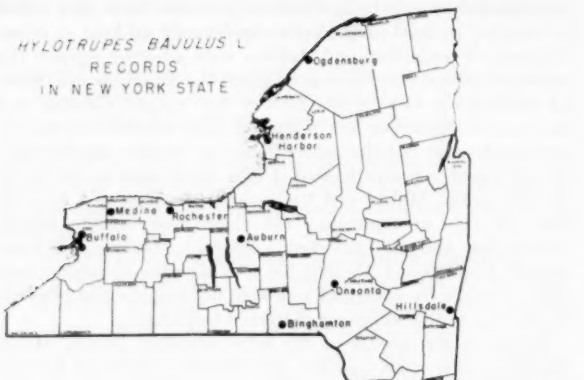

FIG. 1.—Map showing distribution of the old house borer in New York State.

in eastern white pine *Pinus strobus* L., 1954); Oneonta (larva, in western white pine *Pinus monticola* Dougl., 1953); and Rochester (larva, in eastern hemlock *Tsuga canadensis* (L.), 1953.)

Outside of the New York City and Long Island areas and with the exception of Leonard's (1926) citation of the Buffalo collection by Zesch and Reinecke, the records were all made since 1950. We cannot conclude at this time whether or not any significance can be placed on this phenomenon. It is hoped that more records of this kind can be brought together to help resolve whether the old house borer is of growing importance in northeastern United States.

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Some Mites Injurious to Farm-Stored Grain[1]

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Although the granary mite problem in the United States is a minor one as compared to that posed by insect pests of stored products, serious infestations may develop in farm-stored grain. Probably the most significant factor involved in these outbreaks is the maintenance of a high percentage of moisture in the commodity. Water seepage in the bin, storage of damp wheat, lack of adequate air circulation, scarification of the wheat during threshing and storage operations, and accumulation of vegetable debris are conditions which contribute to infestations of major proportions.

The damage caused by mites in stored products may be of a direct or an indirect type. The importance of the injury produced by mites feeding directly on the commodity should not be underestimated. Solomon (1946) described an experiment in which tyroglyphid mites consumed up to 3% by weight of a sample of wheat before dying out. The mites were able to destroy the germ completely, eating little of the remainder when the food supply was adequate. Such injury destroys a considerable portion of the nutritive value of the kernel, since vitamin B and iron are associated primarily with the term tissue and surrounding endosperm.

Mites will not attack grain when the seed coat is intact (Solomon 1946) but since the threshing and storing results in scarification of more than 90% of the kernels, it is possible that over 90% of the grain stored in an infested bin may be injured or destroyed.

Indirect injury may at times overshadow the damage due to direct feeding. The presence of mites in wheat may affect not only the grower, but the miller and the consumer as well. Mite-infested wheat means a loss to the grower who may have to divert his crop from food to feed. The miller who produces flour containing mite fragments is subject to penalties provided under Section 406 of the Federal Food, Drug, and Cosmetics Act. The consumer, who may pay top prices for contaminated foodstuffs, also is affected.

Other types of indirect injury may affect mite-infested grain. Heavy concentrations of granary mites cause a rise in the temperature and moisture content of the grain, and an increase in the growth of microörganisms. Dense infestations of any mite, therefore, may result in serious damage. Causative agents of plant diseases may be transmitted by granary mites, according to Sigrianskii (1940). He reported that *Tyrophagus noxius* Zakh. (= *T. castellanii* Hirst) transmitted *Tilletia caries*, a stinking smut pathogen, from infected to healthy wheat.

Some of the Sarcoptiform mites are of medical importance also. *Tyroglyphus farinae* L. and *Tyrophagus castellanii* Hirst can cause intense irritation of the skin when present in large numbers. Ingestion of certain species of granary mites in infested foods has been mentioned as a cause of various intestinal and stomach disorders in man (Solomon 1943).

Observations on 56 wheat samples collected from 15 western New York State counties revealed the presence of some 24 species of mites, a number of which were found to be directly injurious to the wheat kernel. Without exception these latter forms were identified as belonging to the suborder Sarcoptiformes.

Mites of the suborder Sarcoptiformes inflict damage on the wheat kernel by a process of scraping and gouging of the seed tissue, followed by ingestion of the separated material. Most grain-inhabiting Sarcoptiform mites possess a pair of heavy chelicerae which are bluntly toothed and well adapted for scarification of hard tissue. The fact that these mites ingest solid food particles suggests the necessity for the maintenance of a high moisture content in the infested commodity from which a constant supply of metabolic water may be derived. Such is the case, for grain-feeding mites cannot long survive in wheat which falls below a moisture content of 11%.

The following species of mites were found feeding on grain: *Tyroglyphus farinae* L., *Tyrophagus castellanii* Hirst, *Tyrolichus casei* Oudmns., *Aleuroglyphus ovatus* Troupeau, *Chortoglyphus arcuatus* Troupeau, and *Glycyphagus destructor* Schrank.

Tyroglyphus farinae L., the common granary mite, was observed in 27% of the collected samples. This destructive form occurs not only in grain but also in flour, cheese, dried fruits, linseed, and many kinds of meal. *T. farinae* seems to be the best adapted of the grain-feeding mites, since the injury incurred by this species is of a far greater magnitude than is that of any other acarid. The damage in wheat consists of destruction of the embryo and surrounding tissue, followed by that of the endosperm. In severe infestations, the kernels may be reduced to empty husks. This mite was observed in samples with moisture contents as low as 11.5%.

Tyrophagus castellanii Hirst, sometimes referred to as the cheese mite, was found in 9% of the observed samples. A major pest in cheese, this mite also may be destructive in wheat and other grains. *T. castellanii* prefers broken grains and wheat dust to whole kernels, probably because its chelicerae are not strong enough to be effective in reducing whole grains.

According to Robertson (1946) *Tyrolichus casei* Oudmns. ranks second only to *Tyrophagus longior* Gerv. as an important

Accepted for publication June 3, 1955.

cheese pest in New Zealand. One of the less seldom observed forms in New York State granaries, *T. casei* has not been recorded as being troublesome in stored grain habitats. Only 4% of the collected samples contained individuals of this species, and in no case were they numerous.

Although the chelicerae of *Aleuroglyphus ovatus* Troup. appear to be well suited for doing extensive damage to the whole kernel of wheat in much the same fashion as does *T. farinae*, this mite is of minor importance in stored grain. A common inhabitant of commodities which are high in fat, protein, and moisture, *A. ovatus* was identified from four samples, two of which had a moisture content of more than 14%.

Chortoglyphus arcuatus Troup. is commonly encountered in hay and fodder but occasionally turns up in seed stores, where it feeds on broken grains and dockage. Whole kernels ordinarily are not attacked, although *C. arcuatus* is equipped with an unusually powerful set of chelicerae. This species was found in four samples which ranged in moisture content from 12.4 to 13.9%.

A species indigenous to stored products, *Glycyphagus destructor* Schrank may be found in large numbers in wheat bins. Often found in association with *T. farinae*, this species exhibits food preferences almost identical with those of the common granary mite, i.e. wheat, flour, meal, etc. Unlike *T. farinae*, *G. destructor* rarely attacks whole kernels, feeding for the most part on broken seed. It may increase to enormous numbers, causing considerable damage and creating a difficult contamination problem. *G. destructor* was seen in 11% of the samples which ranged in moisture content from 12.4 to 14.4%.

Several other Sarcoptiform mites were identified from New York wheat samples, the majority of them feeding on vegetable debris, wheat chaff, and molds usually associated with vegetable decay.

Summary—The presence of mites in stored grain can be a definite problem to the grower, processor, and consumer of grain crops. Although only a few species actually feed on the whole grain kernel, infestation of stored grain by any species of mite may result in various forms of indirect injury. Contamination, raising of the moisture content and temperature of the grain, and dissemination of plant disease pathogens may prove more serious than the injury occasioned by mites feeding on the kernels.

A study of 56 wheat samples collected from 15 western New York State counties revealed that mites of the suborder Sarcoptiformes were responsible for the majority of injurious infestations. Six species were found to feed on the wheat kernels. These were *Tyroglyphus farinae* L., *Tyrophagus castellanii* Hirst, *Tyrolichus casei* Oudmns., *Aleuroglyphus ovatus* Troupeau, *Chortoglyphus arcuatus* Troupeau, and *Glycyphagus destructor* Schrank.

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Potentialities of the Otoscope in Entomological Research[1]

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Many times an instrument developed for a specific use has later been adopted to other uses with equal or even greater facility than the original use for which it was intended. The entomological pinning forceps is an example in point of a dental forceps being adopted for use in entomology.

The otoscope has been used for years by practicing physicians to examine the nasal and auditory passages of their patients. The author first became acquainted with the otoscope as a po-

FIG. 1.—The Otoscope in position ready for use. Rotation of the scribed ring, here held between the thumb and forefinger, turns on the light which is adjustable from a low to bright intensity. Photo courtesy of the American Optical Company, New York.

[1] Accepted for publication June 15, 1955.

tential entomological tool in 1944 when this instrument was used to study honey bee larvae in a glass observation hive. The focal length was great enough to permit observation of the honey bee larvae through the glass sides of the observation hive. Since this instrument pin-points a beam of light into small recesses and cavities and offers the added advantage of a magnifying lens it was found to be most useful in studying the movements and reactions of bee larvae to various antibiotics and drugs.

For the past 4 years studies have been conducted concerned with the collection of ectoparasites from sylvatic mammals. The otoscope has become an item of standard equipment on field trips because of its usefulness in inspecting the ears of mammals for chiggers and other small ectoparasites.

It would seem that this instrument could profitably be adopted to many uses in entomological research where a portable unit is required that is capable of producing a small intense beam of light with a built-in magnifying lens. These instruments are currently available with a 2.35× magnifying lens. Figure 1 illustrates the otoscope in position ready for use. Intensity of the beam of light is adjustable by rotation of the scribed ring shown in the accompanying figure.

A Magnetically Suspended Insect Cage[1]

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The need for a small, light-weight, easily attached cage for confining aphids used in virus-vector investigations led to the development of a small cage which is held on a leaf by means of a small magnet placed on the opposite side of the leaf.

The essential parts and the assembly of the cage, as shown in figure 1,[3] are given below.

1. A polished Alnico bar magnet, 19/32×7/32×3/32 inch.
2. A light-weight, rustproof, steel-cadmium-plated washer with 3/8 inch inside and 5/8 inch outside diameter. One side of the washer is covered with a 150-mesh nylon cloth.
3. A celluloid ring about 12 mm. in diameter and 5/16 inch high cemented to the other side of the washer to form the box of the cage. The celluloid ring is cut from a 13-mm. centrifuge tube and reduced slightly in diameter to permit the lid of the cage to fit over the box snugly.
4. The lid of the cage is a celluloid ring 13 mm. in diameter and 5/16 inch high with a celluloid top which is perforated with a needle to prevent condensation of moisture inside the cage.
5. Assembled cage.

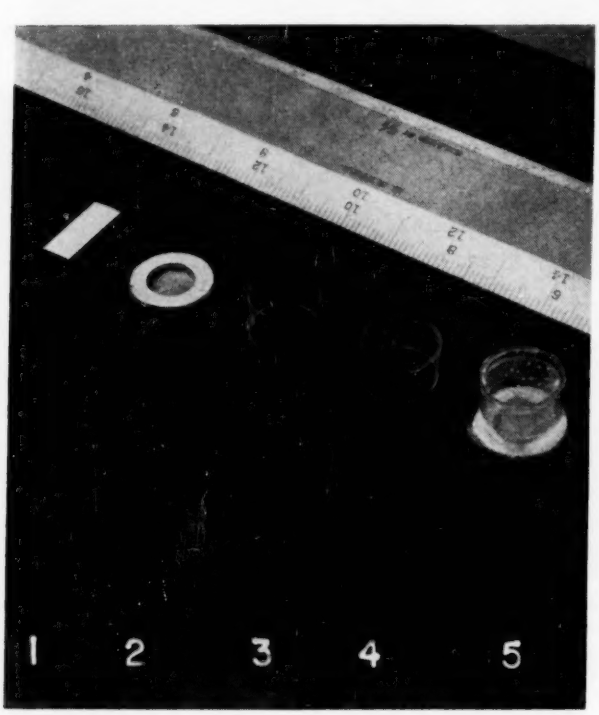

FIG. 1.—Parts and assembly of leaf cage.

FIG. 2.—Leaf cages attached to cherry leaves by means of small magnets.

The suspension of the cages on leaves is shown in figure 2.

For cages larger than the one described above, the bar magnet should be cemented inside of a small celluloid ring cut from a 16-mm. centrifuge tube, to insure a snug attachment to the leaf surface.

Once the cage is charged with the desired number of aphids

[1] Accepted for publication October 14, 1955.

[2] In cooperation with the Utah State College and Experiment Station at Logan, Utah.

[3] John L. Chidester of Utah State College, took the pictures of the cages.

for a test, transfers for serial or timed feedings are accomplished by moving the cage with the test aphids in it. The aphids feed through the cloth mesh. This procedure not only facilitates the manipulation of a test population, but also reduces injury to the insects and prevents any losses or escapes.

Effectiveness of Certain Residual Insecticides in Preventing Emergence of the Bean Weevil from Infested Bean Seeds[1]

ROBERT F. RUPPEL[2]

Bean seeds that are held in storage by the Bean Section of the Office of Special Investigations of the Colombian Ministry of Agriculture and by the Caja de Crédito Agrario are frequently attacked severely by the bean weevil, *Acanthoscelides obtectus* (Say). At Palmira a second species, *Zabrotes subfasciatus* (Boh.) also attacks the stored seed. To protect the seed from these insects, it is dried to 15 to 17 per cent moisture, treated with DDT at a dosage of one kilogram of the technical material per ton of seed in a slurry treater or with this same insecticide as a 5 per cent dust, and bagged in multi-walled paper bags. This procedure has been almost completely effective in protecting the genetic material of the Bean Section, and only a few complaints have been received from users of the improved varieties of the seed distributed by the Caja.

A cause of constant complaint, however, has been the emergence of adult weevils from the beans shortly after they have been treated. The emergence has been due to a combination of factors: infestation from the field, poor storeroom sanitation, and delay in drying and treating the seed. In the search for a product to prevent emergence, a test was made to determine whether insecticides that give the necessary residual protection would also kill the weevils within the seed.

Beans of the variety "Uribe Redondo" that were heavily infested with *A. obtectus* were thoroughly mixed, and the average number of emergence holes in six samples of 50 seeds each was determined. The number of holes ranged from 19 to 23, with an average per sample of 20. Samples of 200 grams of this infested seed were weighed, treated with the insecticides, and sealed in paper bags on July 14, 1953. Three replications were made of each treatment.

On August 17, 1953, each sample was placed on a 4-mesh screen and shaken vigorously over a piece of white paper. The adult weevils that passed through the screen and were able to walk without staggering were collected in aspirators and counted. The weight of the sample was then taken, the weight of the insecticide that had been added was deducted from this weight, and the loss of weight during the period of the test was recorded. The number of emergence holes in 50 seeds from each sample was counted and the average number of holes present before treatment was deducted from each count. Few living larvae were found in the checks and none in the treated samples. The results of the test are presented in table 1.

DISCUSSION.—As the table shows, the materials that best reduced emergence from the seed—heptachlor, chlordane, BHC, aldrin, dieldrin, and isodrin—also significantly reduced the number of active adults and the loss of weight. Endrin caused an appreciable reduction in emergence but apparently did not kill quickly enough to cause a significant reduction in loss of weight. The effectiveness of most of these materials may be attributed to their fumigant effect (DeLong *et al.* 1952, Mistric & Rainwater 1951, Rainwater 1947, Gaines & Scales 1948, Hoffman & Lindquist 1949, Srivastava & Wilson 1947). The fumigant effect of isodrin and endrin is not known to the author. The noticeable difference between the results obtained with DDT as a dust and those with DDT as a slurry indicates that factors other than fumigant effect were responsible for part of the kill within the seed. The effectiveness of the dust treatment may have been due to its penetration into the holes in the beans, while the slurry may have stuck to the surface of the seed or, as noted by Floyd & Smith (1953), may have been absorbed by the seed coat.

Table 1.—Results of residual insecticide treatment of bean seed infested by the bean weevil.

INSECTICIDE	DOSAGE[a]	FORMULATION	MEAN LOSS OF WEIGHT (grams)	MEAN NO. OF HOLES PER 50 SEEDS	MEAN NO. ADULT WEEVILS PER SAMPLE
Pyrenone	b	b	10.70	80.0	47.7
DDT	1.0	Slurry	11.70	110.0	37.0
DDT	1.0	5% Dust[c]	7.00	43.3	20.3
Methoxychlor	1.0	5% Dust	9.30	83.3	38.7
Perthane	1.0	5% Dust	8.67	104.0	100.0
Heptachlor	1.0	5% Dust	3.00	24.7	0.0
Chlordane	1.0	5% Dust	5.00	5.3	12.3
Toxaphene	1.0	5% Dust	9.00	90.0	69.3
Isodrin	1.0	5% Dust	5.33	8.0	0.0
BHC	0.5	2.5% Dust	3.00	11.3	1.0
Aldrin	0.5	2.5% Dust	4.00	21.0	4.3
Dieldrin	0.5	2.5% Dust	5.00	21.3	7.3
Endrin	0.5	18.5% Emul.	10.00	44.0	3.0
Check			10.30	81.7	171.0
L.S.D. at 5% level			2.23	45.0	27.5

[a] Kg. of the active material per metric ton of seed.
[b] A prepared dust ("Pyrenone Grain Protectant," U. S. Industrial Chem. Corp.) containing 0.85 per cent piperonyl butoxide and 0.05 per cent pyrethrum; used at the recommended rate of 1 part of the dust to 500 parts by weight of the seed.
[c] All dusts were prepared by mixing the concentrated wettable powders with talc.

Of the insecticides which gave favorable results in this particular test, several cannot be recommended because of other factors. For example, the high acute toxicity of isodrin makes its general use for seed treatment impractical. And in experiments conducted by this office, BHC has retarded the germination of seeds and has hindered the formation of the secondary roots of seedling plants, while chlordane and dieldrin have reduced the percentage of germination of the seeds.

Of the better materials used in the test, heptachlor and aldrin appear to be the most promising as residual materials that will kill the weevils within the seed. Further experiments are being conducted to test their practicality for seed treatment.

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Biological Control of *Epilachna philippinensis* Dieke in Guam

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The phytophagous ladybeetle, *Epilachna philippinensis* Dieke, which attacks solanaceous plants, was first recorded from Guam in November, 1948, by K. L. Maehler who found it on *Cestrum diurnum* Linn. growing along the airstrip at the U. S. Naval Air Station, Agana. The ladybeetle is believed to have been accidentally introduced into Guam from the Philippines where it is a serious pest. For that reason, the species is commonly referred to in Guam as the "Philippine ladybeetle." In Guam, the ladybeetle is the most serious pest of eggplant and tomato. It also attacks chili pepper and bell pepper as well as several wild plants belonging to the genus, *Solanum;* it rarely attacks tobacco, however. The ladybeetle also occasionally attacks *Bauhinia* spp. and has been known to defoliate zinnia plants. Experimental plantings of Irish potato and garden huckleberry were badly damaged by the ladybeetle.

The first attempt at biological control of *Epilachna philippinensis* was made in November, 1950. Approximately 3100 puparia of the parasitic fly, *Paradexodes epilachnae* Aldrich, were collected in Mexico by H. D. Smith, entomologist with the U. S. Bureau of Entomology and Plant Quarantine, and shipped by air to Guam. As adult flies emerged, they were liberated in the field; M. M. Ross, Staff Entomologist, Naval Government of Guam, made the releases. According to information preserved in the files of the Guam Department of Agriculture, releases were made in 22 areas of the Island. The author conducted extensive surveys during 1951 and 1952 and several thousand ladybeetle pupae were collected from all parts of the Island and placed in the insectary for parasite emergence. No parasites were recovered.

Arrangements were made for further introductions of *Paradexodes epilachnae* during the fall of 1952 and two shipments were received in Guam during October. The first shipment, numbering 600, suffered severe mortality; only 22 adults emerged. The second shipment consisted of 1600 fly puparia, most of which were parasitized by the secondary parasite, *Brachymeria carinatifrons* Gahan. Four hundred sixteen flies were liberated from the second shipment. Further shipments were frustrated by early severe frosts in the collecting areas in Mexico which killed the host ladybeetle pupae, *Epilachna varivestis* Muls., before they could be collected. No recoveries of *P. epilachnae* were made during 1953 and 1954.

In November, 1953, R. P. Owen, Staff Entomologist for the Trust Territory of the Pacific Islands, collected a number of pupae of *Epilachna philippinensis* on Luzon in the Philippines and hand-carried them to Guam where they were held in quarantine in the laboratory. Approximately 100 eulophid parasites were reared from this material. They were identified as *Pleurotropis epilachnae* Rohwer at the U. S. National Museum. An attempt to propagate this species in the laboratory failed as the host larvae were killed by a fungus disease.

On October 2, 1954 the author received a shipment of 26 *Epilachna philippinensis* pupae from Manila. The mature ladybeetle larvae had been parasitized in the laboratory of the Bureau of Plant Industry, Philippines Department of Agriculture and Natural Resources to avoid the inclusion of hyperparasites or other undesirable insects. Approximately 200 *Pleurotropis epilachnae* adults issued from these pupae; 46 died during transit, 100 were released soon after their arrival in Guam, and the remainder were used to establish a breeding colony in the laboratory. Breeding of the parasite was successful and during the ensuing 3 months 3275 parasites were liberated in the field.

Propagation of *Pleurotropis epilachnae* in the laboratory was fairly simple. The usual procedure followed was to expose 5th instar *Epilachna philippinensis* larvae to mated *P. epilachnae* females in large glass jars for 24 to 48 hours. Twenty-five to 50 females placed with 200 or 300 larvae ordinarily produced very good results; as a rule, all larvae were heavily parasitized. In the earlier rearings food was provided for the parasites in the form of small cotton pads soaked in pure honey or saturated sugar solution. It was noted, however, that the parasites fed very sparingly, therefore feeding was discontinued during the latter part of the rearing program with no adverse effects. Both female and male wasps fed readily on body fluids of the host larvae. The average time from egg to adult was 13 to 16 days. Adults were held in large test tubes for 24 hours for mating.

Four months after the initial release of *Pleurotropis epilachnae* a careful survey of the colony sites was conducted. It was found that of the 24 colonies liberated 17 became established. The failure of four of the seven colonies which did not become established was attributed to the destruction of hosts of the ladybeetle or the application of insecticides. Parasitism of ladybeetle pupae averaged 72%. The percentage parasitism was determined by careful counts of ladybeetle pupae *in situ* on host plants in the field. This was possible due to the pronounced difference in color between parasitized and unparasitized pupae. Parasitized pupae develop a dark brown color within a few days following pupation, whereas unparasitized pupae retain the creamy or grayish white color characteristic of the species.

In making counts, approximately 10% of the ladybeetle host plants present at each colony site were selected at random and carefully inspected. All ladybeetle pupae found were counted including those from which adult beetles or parasites had emerged. From these tallies the percentage parasitism was calculated. Doubtful pupae were considered to be unparasitized. Since several days normally are required for the typical brown color of the parasitized pupa to appear, it is possible that some pupae considered to be unparasitized actually were parasitized, in which case the average percentage parasitism would have been higher.

The average number of parasites which issued per pupa was determined by laboratory rearing of ladybeetle pupae collected at random at the various colony sites. The number of parasites which issued varied from 6 to 34; the average was 20.

Observations in the laboratory showed that the *Pleurotropis epilachnae* female normally oviposits in 5th instar larvae. In some instances, oviposition in earlier stages occurred, but, almost without exception, such larvae died without pupating and no parasites issued. This phenomenon was also observed in ladybeetle material collected in the field. Attempts to obtain oviposition in pupae met with no success. Pupae used in these experiments varied from freshly transformed pupae to those several days old.

Tests were made to determine the specificity of *Pleurotropis epilachnae*. Oviposition in larvae or pupae of the common beneficial coccinellids, *Coelophora inaequalis* (Fabr.), *Rodolia cardinalis* (Muls.), and *Coccinella arcuata* (Fabr.) was not obtained. No tests were made with other beneficial species. Since no phytophagous ladybeetles other than *Epilachna philippinensis* occur in Guam, it could not be determined whether or not *P. epilachnae* would attack other species of *Epilachna*.

SUMMARY.—The phytophagous ladybeetle, *Epilachna philippinensis*, a serious pest of solanaceous plants, was first recorded

from Guam in 1948. Attempts during 1950 and 1952 to control the ladybeetle with the parasitic fly, *Paradexodes epilachnae*, had no success. During 1954 a eulophid parasite, *Pleurotropis epilachnae*, was successfully introduced from the Philippines and within 4 months it was exerting 72% control over the ladybeetle. No evidence was found that *P. epilachnae* attacks beneficial coccinellids in Guam.

Daphnids Help to Screen Systemics[1]

E. H. WOLLERMAN and L. S. PUTNAM, *Central States Forest Experiment Station, Forest Service, U.S.D.A.*

A systemic is a non-phytotoxic material capable of being translocated within a plant and which, by its presence, protects the plant against insect attack. When testing such materials, phytotoxicity is easily observed by visible plant reactions. Translocation and toxicity to insects, however, are usually determined by caging live insects and observing mortality as compared with check insects. However, the time required to rear or collect and cage test insects is rather great in testing one systemic. When many chemicals are to be tested, time becomes a limiting factor. We have found that another arthropod (*Daphnia pulex* de Geer, a micro crustacean) can be used as a test animal to guide the rapid screening of systemics.

The use of daphnids as a biological indicator is not new. Anderson (1944) and others have used daphnids for detecting toxic materials in trade wastes. A sensitivity of 0.08 p. p. m. has been found toward some materials. The small size of daphnids (maximum length 5 mm.) permits a great many to be reared in a small space. They are easy to culture, requiring only water containing bacteria or their equivalent for food. Their reproductive rate is high. In her life span of 2 months, a female may produce 400 or more offspring. For precise tests, daphnids may be cultured under conditions limiting reproduction to parthenogenesis and thereby producing a clone culture. The handling of daphnids when conducting tests is a simple matter of taking several hundred from the stock tank with a dipper and distributing them into test dishes with a pipette. The caging required for insect tests is entirely avoided.

In the procedure described here, black locust was used as the test plant. Freshly cut leaf samples of 20 grams were churned with 400 ml. of strained river water for 5 minutes in a Waring blender. (A barrel of water from a river not contaminated by factory wastes gave us a supply of water of constant quality for several months of testing. The chlorine in city tap water, as well as varying pH and mineral content, is undesirable.) The churned leaf mixture was filtered into a suction flask and the filtrate distributed into 5 or 10 petri dishes. Five dishes were used in searching for toxic effects and ten were used in comparison of toxicity. In either case, a control group was similarly made up with leaf extract from untreated plants. Ten daphnids were added to each dish. We separate the filtrate into a number of dishes merely to make it easier to examine and count the daphnids. Using 5 dishes of 10 daphnids each, we have 50 animals to indicate qualitatively the presence of toxicity. Doubling the number of test animals gives results that are statistically more reliable.

A record of motility and numbers was made over a lighted observation box after 1 hour (Fig. 1). Thereafter, observation of the general activity in the dishes was made to determine the time of the next count. Counts have been made at 1½, 2, 3, 4, 8, and 24 hours but the 1- and 2-hour counts are probably the most important. Test animals that do not move are considered dead.

Results of some of our tests are given in table 1. A preliminary test on cut branches of black locust set in 50% dilution of Systox showed 100% mortality of daphnids in extracts of foliage from these branches. This test was followed by tests of branches from trees receiving soil applications.

The black locust trees used were about 1 inch in diameter and varied between 5 and 6 feet in height. They were spaced 7 feet apart in the plantation and so had a profusion of lateral branches to nearly ground level.

Two rates of soil application were made. One group of trees received 200 ml., 400 ml., and 800 ml. of Systox (32% demeton) per tree. Daphnid tests were made with the foliage from these treated trees the next day following soil treatment. The daphnid mortality on a 2-hour test ranged from 94% to 100% over the three treatments. The persistence of the demeton in the tissues of these treated plants was tested 11 days after treatment. The

[1] Accepted for publication May 6, 1955.

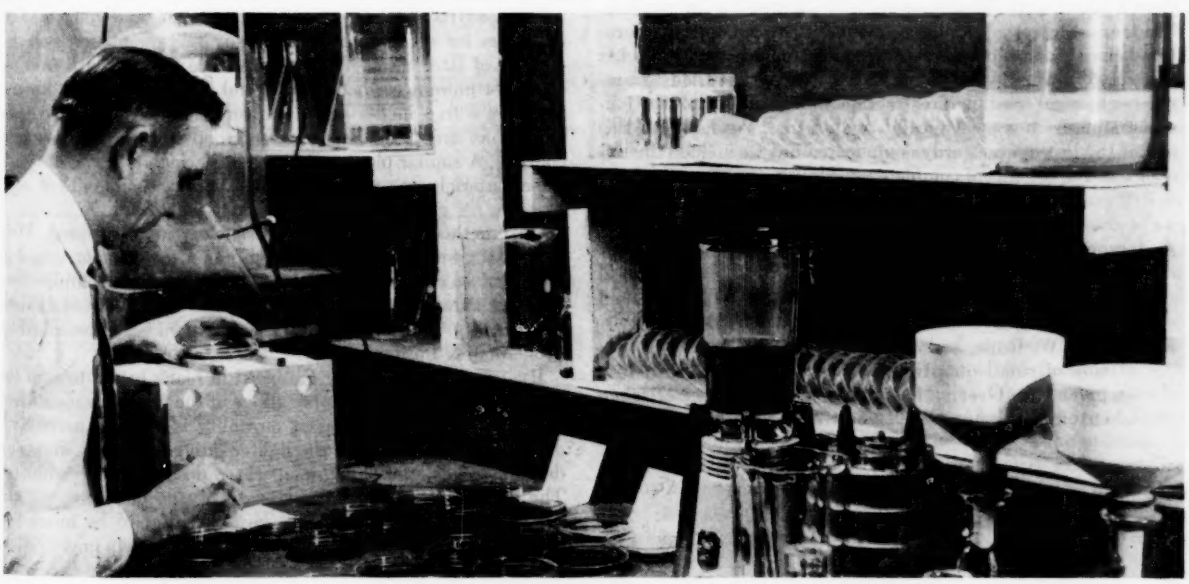

FIG. 1.—Examining test animals (daphnids) over a lighted observation box.

Table 1.—Daphnid mortality in demeton solution applied to soil.

Dosage (Milliliter per Tree)	Total Daphnids	Mortality	
	Number	*Number*	*Per Cent*
Leaf Samples Taken 1 Day After Soil Application: Mortality After 2 Hours			
None	107	10	9
200	107	103	94
400	100	100	100
800	100	99	99
Leaf Samples Taken 11 Days After Soil Application: Mortality After 1 Hour			
None	59	0	0
200	51	51	100
400	59	59	100
800	56	56	100
Leaf Samples Taken 49 Days After Soil Application: Mortality After 1½ Hours			
None	105	2	2
2	115	10	9
10	11	2	2
50	116	102	88

1-hour test showed 100% mortality in all treatments with zero mortality in the controls.

An attempt was then made to show treatment differences by using a lower rate of soil application and increasing the time lapse before testing. Applications of 2 ml., 10 ml., and 50 ml. of Systox were made to each tree of a previously untreated group. After 49 days, foliage samples were taken and daphnid tests were made. The daphnid mortalities in a 1½-hour test indicated that doses of 10 ml. or less are not differentiated from the controls after 49 days. A dose of 50 ml. killed 88% of the daphnids 49 days after treatment.

It should be noted that translocation and toxicity are indicated by arthropod mortality and that there is no possibility of fumigant action.

The methods as described here are the result of little more than 1 year's work. Modifications and adaptations are possible. This research was accomplished and this paper was in preparation before the authors were aware of the publication by Kocher *et al.* (1953). Their work differs in that one part of their test requires chemical treatment, extraction and distillation of the foliage sample from a systemically treated tree. We feel that this makes the test unnecessarily complicated but we include the reference in the interest of complete reporting.

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Control of Black Locust Insects by Systemics[1]

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One of the first questions to be answered in developing a chemical systemic to protect trees from insect attack is how fast and how effectively the systemic can be translocated in the tree. In order to test several systemics on black locust trees, one of about 30 insects that feed on this species was used (*Enchenopa binotata* (Say)), as well as a microcrustacean (*Daphnia pulex* de Geer). The results, although tentative, are encouraging enough to warrant further testing of one or two of the chemicals used.

The use of systemic chemicals to protect plants from insect attack has not been developed as extensively on forest trees as it has been on vegetable food crops. No practical control of a forest insect has been attempted by this method and very little experimental work has been done. Some progress, however, has been made on other trees not classified as forest trees. Bond (1953) reports successful control of a mealybug on coffee trees through trunk application of Hanane. Gasser (1953) claims success with Isolan and Pyrazoxan similarly applied to apple trees for aphid control. Jeppson *et al.* (1952) found that the trunk application of demeton to citrus trees controlled several species of mites.

Entomologists at the Central States Forest Experiment Station, Columbus, Ohio, have investigated the usefulness of systemic chemicals against forest insects in laboratory and nursery tests. The most effective materials tried against insects feeding on trees were found to be demeton, schradan, and the benzene hexachloride group of isomers.

The practical use of these materials, along with method and rate of application, could only be determined by field testing with a species of tree whose value was decreased because of destructive feeding by insects. Such a tree is easily selected in the Central States. Black locust has been planted extensively on strip-mined areas as a nurse crop in forestation programs. Unfortunately, very few locusts can be marketed because of insect damage. Nearly all of the damage is done by the locust borer, *Megacyllene robiniae* (Forst.).

Materials and Methods.—A level area of strip-mine-spoils materials supporting a vigorous planting of 16-months-old black locust was used for the tests. Five materials were applied to the soil: BHC, alpha-beta cake (a by-product derived when lindane is produced from BHC), lindane, demeton, and schradan. Three trees were treated with each material at rates of 2, 10, and 50 grams for BHC, alpha-beta cake, and lindane and 2, 10, and 50 milliliters for demeton and schradan. The quantities were increased in later tests. All materials were diluted with sand or water for more even distribution, and buried in the soil around the trees 3 to 4 inches below the surface. The 15 treated trees were in an area adjoining another group of 15 trees serving as controls. A similar plot was arranged in which treatment by the same materials was made as a foliar spray on one side of each tree.

Two methods for determining translocation were used. Mortality data were taken on the membracid, *E. binotata*, caged in groups of 20 on individual trees. In addition, leaf samples were taken and their extracts evaluated with *D. pulex* to obtain data on mortality. Methods of testing with daphnids are described by Wollerman & Putnam (1955).

Results.—The toxicity produced in black locust toward the insects 42 days after soil applications of the materials mentioned is indicated in table 1. Insect mortality is also compared with daphnid mortality. Since the lighter dosages did not show any definite trends, the data for all three dosages were combined. The daphnid test shows demeton to be the most toxic of the systemics but the insect tests show demeton to be much less effective. Two explanations of these conflicting data might be low

[1] Accepted for publication June 2, 1955.

Table 1.—Effect of soil-treated black locust on *Enchenopa binotata* (Say) and *Daphnia pulex* (de Geer) 42 days after treatment.

Systemic	Per Cent Mortality						
	E. binotata (20 Days After Caging)	*D. pulex* Test Duration (in Hours)					
			1	1½	2	3	5	7
BHC 10% gamma isomer	60		—	—	33	—	74	—
		Check	—	—	16	—	51	—
Alpha-beta cake	38		—	—	12	—	45	—
		Check	—	—	3	—	29	—
Lindane	32		1	—	—	18	—	—
		Check	2	—	—	2	—	—
Demeton	42		—	33	55	—	—	100
		Check	—	2	5	—	—	12
Schradan	37		—	—	26	—	—	—
		Check	—	—	3	—	—	—
Insect Controls	14							

dosage and uneven uptake by the roots. Consequently, tests with larger doses were made.

Table 2 gives data obtained with larger applications of demeton in similar tests. Three general conclusions are indicated: The response for each species is related to dosage; there is similarity between the test animal responses; and the promptness of animal response points to rapid translocation.

Data in table 3 show that the foliar toxicity persists over a long period of time and also that the differences in mortality arising from variations in treatment rate disappear. The data from these tests indicate a relationship between the responses of *E. binotata* and *D. pulex* to foliage from the same treated tree. The use of daphnids in supplementary tests offers a saving of time in the screening of systemic chemicals. The labor of conducting insect tests need only begin with chemicals that are shown to produce a translocated toxin.

The small scale of these tests does not permit recommendations for practical application of the materials mentioned. Tests involving a larger number of trees are necessary. However, additional tests against other insects are encouraged by the results obtained thus far.

Table 2.—How application of demeton to soil around black locust trees affected mortality of test animals 1 day later.

Dosage	Per Cent Mortality	
(Ml.)	*E. binotata* (Caged 1 Day)	*D. pulex* (1 Hour in Leaf Extract)
0	0	9
200	60	94
400	85	100

Table 3.—Mortality rate with *Enchenopa binotata* (Say) on black locust after soil application of demeton and persistent foliar toxicity to *Daphnia pulex* (de Geer).

Dosage (Ml.)	Per Cent Mortality				
	E. binotata (8 Days After Treatment)				*D. pulex* (11 Days After Treatment)
	Caged				
	1 Day	3 Days	7 Days	14 Days	1-Hour Test
0	0	5	10	13	0
200	20	35	50	100	100
450	50	50	55	100	100
908	70	80	80	95	100

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Tests with Dieldrin as a Systemic Against Cattle Grubs[1]

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During the winter of 1953 preliminary studies were conducted at Corvallis, Oreg., to determine the effectiveness of dieldrin as a systemic against cattle grubs, *Hypoderma lineatum* (De Vill.) and *bovis* (L.). Dieldrin and certain other insecticides had been tested as systemics against these grubs during 1952–53 at Kerrville, Tex., by McGregor *et al.* (1954).

Materials and Methods.—Four yearling Herefords were treated with dieldrin and two were used as controls. The insecticide was injected subcutaneously[2] as a 5 per cent suspension in peanut oil at 25 mg./kg. Two injections were given, the first on January 23 when only *lineatum* was present in the backs of cattle, and the second on March 20 when only *bovis* was present.

Observations were made every 10 days on the kill of larvae present at the time of treatment and on those encysting after treatment, but only the total numbers are presented. The larvae that attained maturity were collected by gluing small perforated plastic containers over the cysts just before they dropped. The captured larvae were placed in glass vials containing moistened sand for pupation and emergence as adults.

Results.—The results of these tests are shown in table 1. At the time of the first injection the four treated animals had 43 second- and 58 third-instar larvae and the two control animals had 4 second- and 12 third-instar larvae. Of the 101 larvae present in the treated animals 78 were killed by the treatment. Although none of them died during the first 10 days, 61 were dead after 4 weeks. Most of the larvae that were not killed pupated normally, but none emerged as adults.

Of the 24 larvae that encysted after the first injection 10 were killed, but a few were still alive when the second injection was made. Of the 16 larvae present at the time of the second treatment 8 died and 8 pupated normally but failed to emerge as adults. Eight new larvae encysted after treatment, but 6 of them died and none emerged as adults. Encystment and death following the second treatment were spread over approximately 70 days. From these results it appears that two treatments with dieldrin would be sufficient to control both *lineatum* and *bovis* for the entire season. However, the material failed to prevent larvae from encysting or cutting holes in the backs of the animals.

As can be seen from table 1, there was a very high mortality of the larvae present in untreated animals when the first treatment was given. High mortality of grubs in untreated animals has been encountered by other workers. Of the 11 untreated

[1] Accepted for publication June 13, 1955.

[2] J. O. Schnautz, veterinarian, Oregon State College, made the injections.

Table 1.—Mortality of cattle grubs caused by dieldrin injected subcutaneously at 25 mg./kg.

Animal No.[a]	Larvae Present at Time of Injection				Larvae Encysting After Injection			
	Total	Dead	Pupated	Emerged as Adults	Total	Dead	Pupated	Emerged as Adults
First injection (*lineatum*)								
80	37	35	2	0	14	6	0	0
81	13	6	5[b]	0	0	0	0	0
84	27	24	3[b]	0	7	3	0	0
85	24	12	12	0	3	1	0	0
82	9	8	1	1	7	2	1	0[c]
83	7	3	4	3	10	2	0	0
Second injection (*bovis*)								
80	8	5	3	0	7	6	1	0
81	2[d]	1	1	0	0	0	0	0
84	4	2	2	0	1	0	1[b]	0
85	2	0	2	0	0	0	0	0
82	3	0	3	1	1	0	0	0
83	8	1	7	6	4	2	2	2

[a] Nos. 82 and 83 were untreated.
[b] Pupae lost.
[c] Missing larva killed by host.
[d] *H. lineatum*.

larvae present at the time of the second treatment, 10 pupated and 7 of these emerged as normal adults.

The effectiveness of dieldrin is shown by the fact that no adults emerged from the specimens collected from the treated animals, whereas several emerged from the pupae coming from the untreated animals. Although dieldrin showed considerable promise in these tests it cannot yet be recommended for grub control because of the possibility of excessive residues following its use.

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Effect of Diluents on the Acaricidal Action of Malathion and Aramite in Dusts[1]

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In 1951 and 1952 pyrophyllite was the diluent used in fungicide-insecticide-acaricide dusts applied to roses in field tests at Beltsville, Md., and good control of two-spotted spider mites, *Tetranychus telarius* (L.), was obtained with those that contained Aramite or malathion. In 1953 attapulgite was the diluent used with similar combinations, and poor control resulted. Therefore in 1954 and 1955 a laboratory study was made of various diluents with Aramite and malathion.

Materials and Methods.—The diluents used are described in table 1. It will be noted that three of the materials were used in more than one grade. The same concentration of Aramite (1.5 per cent) or malathion (4 per cent) was used in all tests. The Aramite dusts were prepared from 10 parts of a 15% wettable powder and 90 parts of the diluent, and the malathion dusts from 16 parts of 25% wettable powder and 84 parts of the diluent. Small quantities of these dusts (25 to 50 grams) were mixed in a Waring Blendor.

The dusts were applied to mites in a tower 9.5 inches in diameter and 40 inches high. Each treatment consisted of 0.25 gram of dust (equivalent to approximately 50 pounds per acre) introduced through a small orifice in the bottom of the chamber. A curved piece of 5/16-inch glass tubing slightly tapered on the discharge end served as a micro-duster, and a short blast of compressed air (60 lb./sq. in. gage) as the propellant. Each treatment was allowed 5 minutes for dust settling. The tower was thoroughly ventilated between treatments. All treatments were made between 70 and 75° F. Higher temperatures may mask the differences between diluents with malathion.

Table 1.—Characteristics of diluents used in dusting tests.

Diluent	Surface Mean Diameter (Air Permeation), Microns	Per Cent Under 44 Microns (Wet Sieve)	Bulk Density (Scott Volumeter), Grams/cc.	pH
Attapulgite:				
Commercial A	1.9	67	0.29	8.2
Commercial B	1.7	82	.30	7.5
Special fine	0.2	99.9	.09	8.3
Calcium carbonate:				
Ground calcite	5.3	99.6	.66	9.2
Precipitated chalk	1.0	99.9	.22	11.1
Diatomite	0.5	99.6	.08	5.8
Kaolin	0.5	98	.26	4.7
Montmorillonite	2.5	79	.38	5.1
Pyrophyllite	3.5	84	.49	6.3
Talc:				
Fine commercial	1.8	99	.39	9.0
Special fine	0.5	99	.28	8.3

The Beltsville (nonresistant) strain of two-spotted spider mites was used throughout these tests. Approximately 100 adult mites[3] were transferred to the primary leaves of a young bean plant 5 hours before treatment. Since mites prefer the under surface of the leaves, this surface was turned up while the dust was settling. After treatment the plants were placed in 2- or 4-ounce bottles of water and held in the greenhouse at 70–80° F.

In 1954 eight diluents were replicated three times, and in 1955 the same diluents plus three additional ones were tested with four replications. Each treatment constituted a comparison of one replicate on the same day. Mortality counts were made 24 hours and 1 week after treatment.

Results.—The results of these tests (Table 2) indicate that Aramite was highly effective with calcium carbonate, talc, or pyrophyllite. These dusts gave significantly higher mortalities after 24 hours than those made up with the other diluents. After 1 week, however, dusts containing diatomite, montmorillonite, and the special fine attapulgite gave higher mortalities, chiefly of newly hatched larvae.

The same diluents that formed effective dusts with Aramite were found to be effective with malathion, as were also kaolin, diatomite, and special fine attapulgite (Table 2). Malathion diluted with attapulgite of the normal particle-size grade (A and B), and with montmorillonite of similar particle size, gave lower mortality at both counts.

There was little or no apparent correlation of effectiveness with particle size of the diluent, its bulk density, or its pH. The dependence seemed to be more on mineral composition, though there were exceptions even here. For example, both Aramite and malathion were more toxic to mites when diluted with the special fine attapulgite than with the commercial A dust. Both

[1] Accepted for publication August 4, 1955.
[2] Anthony L. Boswell and Richard Lehr assisted in these tests.
[3] *Tetranychus cinnabarinus* (Boisd.)

Table 2.—Mean per cent mortality of two-spotted spider mites from Aramite and malathion in dusts with different diluents. 1954–55.

	ARAMITE 1.5%				MALATHION 4%			
	24 Hours		1 Week		24 Hours		1 Week	
DILUENT	1954	1955	1954	1955	1954	1955	1954	1955
Attapulgite:								
Commercial A	15	24	30	32	53	42	41	53
Commercial B	16	24	24	37	52	41	40	64
Special fine	—	50	—	80	—	87	—	92
Calcium carbonate:								
Ground calcite	96	98	95	99	100	94	98	85
Precipitated chalk	—	84	—	91	—	92	—	85
Diatomite	13	68	42	82	90	87	67	81
Kaolin	12	9	25	30	100	92	97	86
Montmorillonite	37	60	49	78	58	56	42	65
Pyrophyllite	94	98	100	95	100	93	99	86
Talc:								
Fine commercial	99	97	99	91	100	96	94	93
Special fine	—	91	—	94	—	96	—	91
L.S.D. at 5% level	30	17	24	17	30	14	17	13
L.S.D. at 1% level	41	24	34	23	41	19	24	17

these products were from the same source. Further studies are contemplated under more specific conditions as to physical character of carrier or diluent.

Oklahoma Tabanidae[1]

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Tabanids are among the most serious arthropod pests of Oklahoma livestock. Their importance is due to the direct loss of blood caused by their feeding and to the transmission of diseases such as anthrax and anaplasmosis.

The following list of tabanids was compiled to indicate species present in Oklahoma, the dates when they were found, and to list several new State records. The authors wish to thank Dr. C. B. Philip and Dr. Alan Stone for identification of several of the more difficult specimens that were examined in the study. Specimens were taken from the authors' personal collections, field collections and reared specimens from a two-year cooperative study involving the A.R.S. Entomology Research Branch, Kerrville, Texas and the Oklahoma A. and M. College. *Tabanus sparus* subsp. *milleri* Whitney, *T. orbicallus* Philip, and *T. vittiger* subsp. *schwardti* Philip were not found by the authors but are taken from Philip's records (1947) for completeness. *Hybomitra sonomensis* (O.S.) was found only in the University of Oklahoma collection.

The taxonomic arrangement of the following list is taken from Philip (1947). Nine genera and 70 species have been collected in Oklahoma.

TABANIDAE Osten Sacken, 1875

Subfamily PANGONIINAE Lowe, 1860
Tribe PANGONIINI Enderlein, 1922.
Genus ESENBECKIA Rondani, 1863.
1. *Esenbeckia incisuralis* (Say), 1823.
14–29 June.
Tribe CHRYSOPINI Enderlein, 1922.
Genus SILVIUS Meigen, 1820.
1. *Silvius notatus* (Bigot), 1892.*
30 August.
2. *Silvius pollinosus* Williston, 1880.
8 June–5 October.
3. *Silvius quadrivittatus* (Say), 1823.
9 June–27 August.
4. *Silvius quadrivattatus* subsp. *texanus* Pechuman, 1938.
22 September.
Genus CHRYSOPS Meigen, 1800.
1. *Chrysops aestuans* van der Wulp, 1867.*
7–19 July.
2. *Chrysops brunnea* Hine, 1903.*
12–28 June.
3. *Chrysops callida* Osten Sacken, 1875.
26 May–13 August.
4. *Chrysops celeris* Osten Sacken, 1875.
29 April.
5. *Chrysops flavida* Wiedemann, 1821.
1 June–21 September.
6. *Chrysops fulvaster* Osten Sacken, 1877.
7–19 July.
7. *Chrysops geminata* Wiedemann, 1828.*
9–19 June.
8. *Chrysops inda* Osten Sacken, 1875.*
3–28 July.
9. *Chrysops moecha* Osten Sacken, 1875.
6–26 June.
10. *Chrysops montana* Osten Sacken, 1875.*
19 June.
11. *Chrysops nigra* Macquart, 1838.*
23 May–6 June.
12. *Chrysops obsoleta* Wiedemann, 1821.*
6 June–23 July.
13. *Chrysops pikei* Whitney, 1904.
16 June.
14. *Chrysops pudica* Osten Sacken, 1875.*
16 June.
15. *Chrysops sackeni* Hine, 1903.*
25 April.
16. *Chrysops separata* Hine, 1907.
20 April–22 June.
17. *Chrysops sequax* Williston, 1887.
9 June–28 August.
18. *Chrysops univittata* Masquart, 1855.*
26 June.
19. *Chrysops vittata* Wiedemann, 1821.*
6 June–7 August.
20. *Chrysops wiedemanni* Krober, 1926.*
5 June–6 August.
Subfamily TABANINAE Loew, 1860
Tribe CHLOROTABANINI Philip, 1941
Genus CHLOROTABANUS Lutz, 1909.
1. *Chlorotabanus crepuscularis* (Bequarert), 1926.*
10 June–5 August.
Tribe TABANINI Enderlein, 1922.
Genus ATYLOTUS Osten Sacken, 1876
1. *Atylotus bicolor* (Wiedemann,) 1821.*
22 July.
Genus ANACIMAS Enderlein, 1923.
1. *Anacimas dodgei* (Whitney), 1879.
14 April–13 May.
Genus LEUCOTABANUS Lutz, 1913
1. *Leucotabanus annulatus* (Say), 1823.*
29 June–21 July.
Genus HYBOMITRA Enderlein, 1922
1. *Hybomitra difficilis* (Wiedemann), 1828.
8 April–20 May.
2. *Hybomitra lasiophthalma* (Macquart), 1828.*
15 April–28 July.
3. *Hybomitra patulus* (Walker), 1848.
15–30 April.

[1] Accepted for publication August 10, 1955.
* Indicates new State record.

4. *Hybomitra sonomensis* (O.S.), 1877.*
14 April.

Genus TABANUS Linnaeus, 1758.

1. *Tabanus abactor* Philip, 1936.
10 June–29 September.
2. *Tabanus abdominalis* Fabricius, 1805.
2 July–8 September.
3. *Tabanus americanus* Forster, 1771.*
9 June–14 August.
4. *Tabanus atratus* Fabricius, 1775.
6 June–8 October.
5. *Tabanus calens* Degeer, 1776.
9 July–21 September.
6. *Tabanus cymatophorus* Osten Sacken, 1876.*
6–26 August.
7. *Tabanus equalis* Hine, 1923.
22 May–28 July.
8. *Tabanus fairchildi* Stone, 1938.
3 June–23 August.
9. *Tabanus fulvulus* Wiedemann, 1828.*
16 June–24 August.
10. *Tabanus fulvulus* subsp. *pallidescens* Philip, 1936.
7 July–29 August.
11. *Tabanus fuscicostatus* Hine, 1906.*
1 June–24 September.
12. *Tabanus lineola* Fabricius, 1794.
17 April–16 August.
13. *Tabanus lineola* subsp. *scutellaris* Walker, 1850.
17 April–25 September.
14. *Tabanus longus* Osten Sacken, 1876.
9 July–20 August.
15. *Tabanus melanocerus* Wiedemann, 1828.*
6 June–7 July.
16. *Tabanus molestus* Say, 1823.*
3 June–6 August.
17. *Tabanus mularis* Stone, 1935.
21 June–9 July.
18. *Tabanus nigrescens* subsp. *atripennis* Stone, 1935.
14–29 June.
19. *Tabanus nigripes* Wiedemann, 1821.*
12 June–9 July.
20. *Tabanus orbicallus* Philip, 1936.
21. *Tabanus proximus* Walker, 1848.
6 August–19 September.
22. *Tabanus pumilus* Macquart, 1838.
10 June–30 July.
23. *Tabanus punctifer* Osten Sacken, 1876.
11 June–24 August.
24. *Tabanus quinquevittatus* Wiedemann, 1821.
23 June–19 August.
25. *Tabanus reinwardtii* Wiedemann, 1828.*
15 June–8 July.
26. *Tabanus sackeni* Fairchild, 1934.
20 June–19 September.
27. *Tabanus sagax* Osten Sacken, 1876.
3 August–21 September.
28. *Tabanus sparus* subsp. *milleri* Whitney, 1914.
29. *Tabanus stygius* Say, 1823.*
12 June–19 July.
30. *Tabanus sublongus* Stone, 1938.
7 July–27 August.
31. *Tabanus sulcifrons* Macquart, 1855.
20 Juue–24 October.
32. *Tabanus trimaculatus* Palisot de Beauvois, 1807.
27 May 25 August.
33. *Tabanus venustus* Osten Sacken, 1876.
2 June–17 August.
34. *Tabanus vittiger* subsp. *nippontucki* Philip, 1942.*
3–22 August.
35. *Tabanus vittiger* subsp. *schwardti* Philip, 1942.
36. *Tabanus wiedemanni* Osten Sacken, 1876.*
17 June–19 July.
37. *Tabanus zythicolor* Philip, 1936.
15 July.

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Resistance to Ovicides by Eggs of the Body Louse[1]

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In view of the widespread resistance of insects and other arthropods to insecticides, it seemed desirable to know whether eggs would become resistant to ovicides. Preliminary tests to obtain this information were conducted early in 1955 at Orlando, Fla., with selected ovicides against eggs of the body louse, *Pediculus humanus humanus* L.

Resistance of body lice to DDT has been reported by several workers (Hurlbut *et al.* 1952, 1954; Barnett & Knoblock 1952; Eddy 1952; and Busvine 1953). Yasutomi (1952) reported on the development of resistance to BHC and DDT, and Eddy *et al.* (1955) on resistance to DDT, lauseto neu, lindane, pyrethrins, and pyrethrins plus a synergist in laboratory colonies.

Lice from two laboratory colonies were used—the extremely DDT-resistant Korean strain, described by Eddy *et al.* (1955), which has been maintained since 1951 on cloth impregnated with a 0.01 per cent solution of DDT, and the regular colony that has been reared in the laboratory since 1942 with no exposure to insecticides.

Lauseto neu, lindane, and dinitroanisole were selected as test ovicides. Lauseto neu has been found to be a good louse ovicide (Eddy & Carson 1948). It is a chlorinated hydrocarbon, a group to which insects in general have been especially prone to develop resistance, and the Korean colony found to be resistant to DDT has also recently shown very high resistance to it. In tests against adults of this colony the resistance to lauseto neu was about 400 times that of the nonresistant colony at the time the tests reported in this paper were conducted. Although subject to some variation from one generation to another, the minimum concentration required to cause 100 per cent mortality of the F_{50} generation of the resistant colony was 10 per cent, and for the nonresistant colony 0.025 per cent.

Lindane, another chlorinated hydrocarbon, has also been found to be a fairly good ovicide, and the Army uses it in a louse powder against DDT-resistant lice. Lice from the Korean DDT-resistant colony had become about twice as resistant to lindane as the regular colony at the time these tests were made. The minimum concentration required to give complete kill of lice of the F_{50} generation was 0.001 per cent, as compared with 0.0005 per cent for the regular colony.

Dinitroanisole has been used as an ovicide in a pyrethrum louse powder by the Army since 1942.

The methods used to test the ovicides were modifications of those described by Bushland *et al.* (1944) and Eddy (1944). Cloth pads approximately ½ inch square, each bearing 50 to 100 eggs up to 2 days old, were dipped in acetone solutions of the test compounds, and then impaled on pins mounted on boards and kept at 82° F. and 60 to 70 per cent relative humidity until

[1] Accepted for publication August 8, 1955. This work was conducted at the Orlando, Fla., laboratory of the Entomology Research Branch under funds allotted by the Department of the Army.

Table 1.—Effectiveness of three ovicides against eggs of resistant and nonresistant body lice.[a]

Material and Per Cent Concentration	Per Cent Kill of Eggs	
	Resistant	Nonresistant
Lauseto neu		
10.0	15	61
5.0	15	55
2.5	17	61
1.0	14	65
0.5	15	62
.25	22	66
.1	21	38
.05	15	23
.025	11	22
.01	16	18
Lindane		
1.0	92	95
0.5	78	72
.25	36	29
.1	22	17
.05	15	15
.025	15	16
.01	13	10
Dinitroanisole		
10.0	84	72
5.0	51	62
2.5	50	61
1.0	58	50
0.5	46	55
.25	40	50
.1	37	41
Untreated check	14	10

[a] Average of three tests.

the eggs had ample time to hatch. The mortality was determined after hatching was completed in an untreated lot of eggs, usually about 14 days later.

The results are shown in table 1. The eggs of the resistant lice showed high resistance to lauseto neu, but none to lindane and dinitroanisole. The mortality of eggs from resistant lice at all concentrations of lauseto neu was about the same as that of normal eggs at the lowest concentration and that in the untreated check.

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Parasites of the European Corn Borer Found Infesting the Stalk Borer[1]

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Work on parasites of the European corn borer, *Pyrausta nubilalis* (Hbn.), conducted during the period 1919–40 has been thoroughly covered by Baker *et al.* (1949). In addition to information on biology, rearing techniques, field releases, and recoveries, minor attention was given to the transference of exotic parasites to native borers. Studies at that time showed that three of the exotic parasites established in the United States were recovered from native *Pyrausta* but were not found in other genera.

Blickenstaff *et al.* (1953), in reporting on corn borer parasites in Iowa, listed a number of native parasites attacking the European corn borer, but did not mention any work on the transfer of exotic parasites to native borers.

Studies on parasitization of native lepidopterous larvae by exotic parasites were practically abandoned until 1952, when rather extensive collections were made in Iowa by Schaffner (1953). In addition to a number of native parasites, the exotic European corn borer parasite *Lydella stabulans grisescens* R. D. (Diptera, Larvaevoridae) and *Sympiesis viridula* (Thompson) (Hymenoptera, Eulophidae) were reared from the stalk borer, *Papaipema nebris* (Guen.). This was the first record of exotic parasites of the European corn borer successfully parasitizing larvae in genera other than *Pyrausta* under field conditions in the United States.

In 1954 further collections of miscellaneous lepidopterous larvae were made in Iowa, and parasites were reared from them at the European corn borer laboratory at Ankeny, Iowa. *Lydella grisescens* and *Sympiesis viridula* were again reared from the stalk borer.[4]

Lydella grisescens was obtained from 23 of the 24 collections of stalk borers which were taken in late June and July. In central Iowa the first adults of *Lydella* emerged from the stalk borer on July 2. On that date only 50 per cent of the European corn borer larvae had reached the second or third instar, although a few of the earliest batch were somewhat more mature. *Lydella* can successfully parasitize second- and third-instar corn borer larvae, but chances of survival and emergence are not so good as in fourth- and fifth-instar borers. It was thus apparent that one generation of *Lydella* was produced on the stalk borer before parasitization of the bulk of the first generation of European corn borers occurred. There was no possibility of *Lydella* passing the winter in the stalk borer, since this species overwinters in the egg stage.

The development of *Sympiesis viridula* on the stalk borer was similar to that of *Lydella grisescens*, with adults emerging at the same time.

[1] Accepted for publication August 12, 1955. In cooperation with the Iowa Agricultural Experiment Station, Ames, Iowa. Journal paper No. 2754 of the Iowa Agricultural Experiment Station.

[2] Entomology Research Branch, Agr. Res. Serv., U.S.D.A.

[3] Iowa State College.

[4] Identifications of the parasites were made by C. W. Sabrosky and B. D. Burks of the Entomology Research Branch.

Field observations and laboratory rearings of *Lydella grisescens* have indicated a rather poor synchronization between this parasite and the European corn borer. *Lydella* adults start emerging 7 to 10 days before the corn borer moths emerge, and with a preoviposition period of 5 to 7 days the earliest emerging individuals are ready to parasitize corn borer larvae by the time, or even before, moths appear. If one adds to this the preoviposition period of the moths, plus the incubation period of their eggs, and an additional 7 to 10 days before larvae are developed sufficiently for successful parasitization, it becomes apparent that most of the *Lydella* parasites would be dead or at least beyond their prime before corn borer larvae would be available as suitable host material. Since they are able to parasitize the earlier developing stalk borers they are able to produce one generation in this host, and emerge at the time the first-generation corn borers are suitable for parasitization. Thus the stalk borer serves as a good supplementary host, and provides an explanation for some of the differences in parasite populations that occur in different areas of the country.

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Reports of Cooperative Research on Insect Control in Farm-Stored Grain, July 1941 to June 1946

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During the period July 1, 1941, through June 30, 1946, a program of cooperative research on the control of stored grain insects was conducted in the North Central States. The cooperating agencies were the U. S. Department of Agriculture, the Commodity Credit Corporation, and the Agricultural Experiment Stations of Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota.

The results of this program of research were summarized at quarterly intervals and a series of 20 reports totalling 580 pages were mimeographed and distributed to interested agencies. This series of reports contains a vast amount of information concerning the biology and control of stored-grain insects, much of it as yet unpublished.

In order to make these data available for reference, several sets of the reports, as indicated below, have been deposited in agricultural libraries, and may be consulted there.

The reports are available in the following places:

1. U. S. Department of Agriculture Library, Washington 25, D. C.
2. U. S. Department of Agriculture, Stored-Product Insects Section, AMS, Washington 25, D. C.
3. Canada Department of Agriculture, Agricultural Library, Science Service Bldg., Ottawa, Ontario, Canada.
4. Entomology Library, 112 Agriculture Hall, University of California, Berkeley 4, Calif.
5. Library, Iowa State College, Ames, Iowa.
6. Library, Illinois State Natural History Survey, Room 183, Natural Resources Building, Urbana, Ill.
7. Department of Entomology, Kansas State College, Manhattan, Kans.
8. Stored-Product Insects Laboratory, U. S. Department of Agriculture, P. O. Box 191, Manhattan, Kans.
9. Entomology Library, Institute of Agriculture, University of Minnesota, St. Paul 1, Minn.
10. Agricultural Library, Mumford Hall, University of Missouri, Columbia, Mo.
11. Agricultural College Library, University of Nebraska, Lincoln 3, Nebr.
12. Comstock Memorial Library, Comstock Hall, Cornell University, Ithaca, N. Y.
13. Library, North Dakota Agricultural College, Fargo, N. D.
14. Library, Documents Section, Oklahoma A. & M. College, Stillwater, Okla.

The subject matter contained in this series of reports covers a wide range of investigations and the following index was prepared to facilitate the use of the data as reference material; (the first figure in the reference is the report number, and the figures in parentheses indicate the page numbers):

BHC, insecticidal value of, against stored-grain insects, 20 (10–11).
Black flour beetle (*Tribolium madens* Charp.) biology of, 4 (38).
Damage to stored wheat by insect feeding, 11 (30); 14 (12); 15 (3–7); 18 (8, 12); 19 (5–8).
Dockage, effect of, on insect development in wheat, 6 (41–43); 7 (31–33); 9 (21–24); 10 (41–43); 11 (23–25); 12 (35–37); 14 (31–35); 16 (11–14); 17 (16–18); 18 (19–26); 19 (9–16); 20 (1–6).
Dusts, protective, for wheat, 11 (16); 12 (22–26); 13 (18–21); 14 (19–24); 15 (8–10); 17 (11–14); 18 (16–18); 20 (7–11).
Fumigants, effects of, on viability of grain—See Germination, effects of fumigants on.
Fumigants, rate of penetration in grain, 13 (16); 14 (16–18).
Fumigants, retention of, in stored grain, 3 (16); 5 (28); 7 (22); 8 (19); 10(33–36).
Fumigants, tests of new, 3 (23).
Fumigants, effects of, on milling and baking qualities of wheat, 9 (15–16); 10 (37–40); 11 (17–22); 12 (27–29); 13 (22–29); 14 (25–26).
Fumigation of stored grain, 1 (17–19); 2 (11–12); 3 (16); 4 (18–21); 5 (10–14); 5 (24–28); 5 (29); 6 (7–9); 6 (18–22); 7 (17, 20–21); 8 (15–18); 9 (8–16); 10 (25–40); 11 (15); 13 (10–17); 14 (13–18); 15 (8–10); 17 (6–10); 18 (13–15).
Germination, effects of fumigants on, 4 (14–17); 5 (28); 6 (23–26); 7 (17–19); 8 (20); 9 (13–16); 10 (37–40); 11 (17–22); 13 (22–27).
Grain bin floors, 3 (9).
Grain temperatures, 1 (12); 2 (9); 3 (1–4); 4 (1–7); 5 (1–7); 6 (1); 7 (1–2); 8 (1–3); 10 (19–22).
Insect abundance in stored shelled corn, 1 (2–16); 2 (4–10); 3 (1–4); 4 (1–4); 5 (1–5); 6 (1–6); 7 (1); 8 (1–3); 9 (1); 10 (1).
Insect abundance in stored wheat, 1(22–25); 1 (29); 2 (16–21); 3 (5–7); 4 (8–10); 5 (17, 22–23); 6 (11–17); 7 (3–16); 8 (6–12); 9 (1–7); 10 (1–5); 10 (19–22); 11 (1–14); 12 (1–17); 13 (1–8); 14 (1–7); 15 (1–2); 16 (1–3); 17 (1–4); 18 (1–5); 19 (1–4).
Insect distribution in wheat stored in metal bins, 9 (4–7); 10 (8–13); 11 (3–6); 12 (3–6).
Insect—moisture traverses, 3 (9–15).
Moisture and temperature requirements of stored-grain insects, 1 (30–34); 2 (22–25); 3 (19–22); 4 (25–30); 5 (31–37); 6 (37–43); 7 (26–30); 8 (22–23); 9 (17–20); 10 (44–45); 11 (26–29); 12 (30–34); 13 (30–37); 14 (27–36); 15 (11–17); 16 (9–14); 17 (15–18); 18 (19–26); 19 (9–16); 20 (1–6).
Oil sprays for surface treatment of shelled corn, 1 (19–21); 2 (13–15).
Sampling methods, 3 (17–18); 4 (22–25); 7 (23–25); 8 (13–14); 10 (23–24).
Sorghum grain, fumigation of, 5 (30); 17 (6–10); 18 (13–15).
Sorghum grain, insects in, 5 (30).
Soybeans, insects in, 5 (41–45); 6 (10); 7 (3–5).

Temperature and moisture requirements of stored grain insects, 1 (30–34); 2 (22–25); 3 (19–22); 4 (25–30); 5 (31–37); 6 (37–43); 7 (26–30); 8 (22–33); 9 (17–20); 10 (44–45); 11 (26–29); 12 (30–34); 13 (30–37); 14 (27–36); 15 (11–17); 16 (9–14); 17 (15–18); 18 (19–26); 19 (9–16); 20 (1–6).
Temperature requirements of stored-grain insects, 3 (1–4).
Traps, insect, 1 (26–28); 4 (10–11); 5 (18–21); 10 (13–19); 14 (8–9); 18 (6–7).
Turning and screening, 1 (2); 2 (1–4); 3 (4); 4 (4); 5 (8); 9 (3); 10 (6–7).
Turning wheat in cold weather, 3 (8); 4 (11–13); 6 (31–33); 7 (7–15).
Wall treatments for wooden farm granaries, 4 (31–32); 5 (38–40); 6 (29–30); 6 (35–36); 8 (21); 12 (18–21); 13 (8–9); 14 (10–12); 16 (6–8); 17 (5); 18 (8–12).
Wheat, cost of storage, 3 (18).
Wheat storage, 1 (22); 2 (16); 3 (5); 4 (8); 5 (15); 6 (11).
White paint, effect of painting metal grain bins with, 6 (27–28).
Winter grain temperatures, effects of, on stored-grain insects, 4 (1–3); 16 (4–6).

Pink Bollworm Moth Collections in Airplane Traps[1]

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In 1954 airplane flights using special traps were made in the Lower Rio Grande Valley of Texas to determine the occurrence of the pink bollworm moth, *Pectinophora gossypiella* (Saund.) in the upper air. There was evidence that the recent rapid spread of this insect resulted from migration of the moths.

Pink bollworm migration studies by use of airplane traps were first conducted by the writer in 1928 in the Laguna District of Mexico (Glick 1939). Seven of the moths were collected at altitudes from 100 to 3000 feet.

In the 1954 studies a Piper Cub plane was equipped with similar traps adapted to fit on the plane as portable units (Fig. 1). The plane was piloted by Arthur Gieser of the Plant Pest Control Branch, and the flights were made from August 18 to September 3. Four flights were made each day at different times between 5 A.M. and 10 P.M. In 46 flights 10-minute exposures were made 239 times at heights ranging from 100 to 5000 feet. The plane was flown at 50 miles per hour while the collections were being made.

Twelve pink bollworm moths were collected at altitudes up to 1000 feet and under various atmospheric conditions, as shown in table 1. One was taken at 1000 feet over the King Ranch in the middle of the day when the air was rough and convection very strong. Since the nearest cotton was 10 to 15 miles away, this moth was probably carried in the southerly winds from the cotton area of the Lower Rio Grande Valley. The prevailing wind in the Valley is from the southeast. Pink bollworm moths are more active when the wind velocity is 6 miles an hour or less, as determined from light-trap collections. However, in the airplane collections moths were taken when the wind was 20 miles an hour.

FIG. 1.—Piper Cub plane equipped with insect traps placed underneath wings with control wires running from traps to cabin. A screen is partly pulled out of closed compartment for exposure as when in operation.

Table 1.—Records of pink bollworm moth collections in the upper air, together with meteorological data, August 20 to September 3, 1954.

Date	Time of Day	Altitude (Feet)	Wind		Air Condition	Number of Moths[a]
			Direction	m.p.h.		
Aug. 20	5:59 A.M.	200	SE	8	Rough	1 M
23	12:08 P.M.	1000	Calm	—	Rough	1 M
24	6:03 A.M.	100	Calm	—	Smooth	1 F
	5:41 A.M.	500	Calm	—	Smooth	1 F
	11:10 A.M.	200	ESE	8	Smooth	1 F
	11:48 A.M.	1000	ESE	8	Rough	1 ?
25	6:39 P.M.	100	E	20	Smooth	2 F
28	5:59 P.M.	500	ENE	11	Slightly rough	1 M
30	11:44 A.M.	200	NNE	8	Rough	1 M
Sept. 1	6:28 P.M.	100	E	17	Slightly rough	1 M
3	8:28 A.M.	1000	N	6	Smooth	1 F

[a] M, male; F, female.

Light traps were operated on a 100-foot water tower and on the roof of a hotel in Brownsville, also at 100 feet, to determine the response of the moths to lights at this height, and to supplement the collections for the lower altitude airplane flights. The traps were fitted with 15-watt black-light fluorescent lamps. During the period of the flights 41 pink bollworm moths were taken in the trap on the hotel roof, and two in the trap on the water tower.

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[1] Accepted for publication August 12, 1955.
[2] In cooperation with the Texas Agricultural Experiment Station.

Three Methods for Extracting Thrips and Other Insects from Rose Flowers[1]

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To determine the population of flower thrips, *Frankliniella triciti* (Fitch), and other insects in roses at Beltsville, Md., three methods for extracting them from the flowers were compared in 1954. These insects were extracted and counted from random samples of flowers from six rose plots that had been treated experimentally with insecticides for thrips control.

EXTRACTION WITH A DETERGENT.—Each sample of flowers was stirred for 10 minutes in a battery jar, 8 inches high and $6\frac{3}{4}$ inches in diameter, containing a solution of Aresket 300. A stock solution of Aresket was first prepared by dissolving 40 grams in water to obtain 100 ml. Four mls. of this solution, containing 1.6 grams of Aresket was added to each liter of water in the battery jar. After the solution has set for 2 minutes to allow the thrips to settle, the plant material is skimmed off and about half the liquid decanted. Thrips and other insects are then readily counted by placing the jar over cross-section paper.

[1] Accepted for publication August 12, 1955.

Table 1.—Numbers of insects extracted from rose flowers by different methods.

Method	Flower Thrips		*Orius insidiosus*	
	Adults	Nymphs	Adults	Nymphs
Turpentine repellent	1,248	—	18	1
Detergent	1,206	—	12	0
Rearing	990	888	55	115
L.S.D. at 5% level	—[a]	—	28	—

[a] Not significant by the F test.

This method was first used by the late A. C. Davis to extract mites from mushroom compost and found useful by the junior author in extracting cyclamen mites and gladiolus thrips from host plant material. In these early tests 0.8 gram of Aresket per liter was less effective than 1.6 gram.

Liquid detergents such as Triton X-100 or Glim at the rate of 2 ml. per liter of water were found to be as effective as Aresket. However, these materials produced more foam, which increased the difficulty of counting. Solutions containing 0.8 gram of either Dreft or All per liter of water also extracted thrips from flowers, but they were too dark for rapid detection of the thrips.

Turpentine Repellent.—Turpentine as an insect repellent was first reported by Ripley & Hepburn (1929) and was used for extracting thrips from blossoms by Evans (1933). In our tests rose flowers were placed on a wire rack suspended above water in a battery jar. Cotton moistened with turpentine was fastened near the top, and the jar was covered with a plastic sheet, and allowed to set overnight. The thrips were counted as in the detergent method.

Rearing Method.—This method was used by Hills & Taylor (1951) in studies of a dipterous leaf miner and its parasites. In the tests with flower thrips rose flowers were placed in a 1-quart ice cream carton with a hole in the bottom near the rim into which a test tube had been inserted. The carton was placed on its side with the bottom directed toward a constant source of light and rotated so that the test tube was at the 12-o'clock position. The test tube was held horizontally. The tendency of insects to climb, their attraction to light, and the slow drying of the flowers provided the impetus for the insects to collect in the test tube. They were removed from the test tube and identified daily for 10 days in order to avoid their destruction by predatory spiders and insects.

Comparative Results.—Each sample consisted of five flowers collected at random from roses of the Peace variety. These samples were subjected to the three methods of thrips extraction described above. The results, given in table 1, indicate no difference between methods for the number of adult flower thrips recovered, but significantly more adults of *Orius insidiosus* (Say) were extracted by the rearing method. However, this increase was due to adults emerging from nymphs developing in the declining rose flowers during the 10-day extraction period. These data indicate that the rearing method gives a more accurate estimate of the potential flower thrips and *insidiosus* populations.

The detergent method proved to be the most useful for rapid extraction of thrips present at the time of sampling. This method removed all the thrips from the flowers, whereas by the turpentine method approximately 20 per cent were found dead in the flowers. The rearing method required considerably more time for extraction, since the test tube had to be cleaned out each day and at the end of 10 days approximately 20 per cent of the insects were found dead in the cartons.

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Marked Suppressing Action of Schradan on the Walnut Aphid[1]

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Investigations with schradan for the control of the walnut aphid, *Chromaphis juglandicola* (Kltb.) were started in 1953. The results to the present time have been most outstanding and the control obtained has not been approached by any aphicide so far used in our walnut insect investigations. The principal material used contained 1.56 pounds of octamethylpyrophosphoramide and 0.44 pound of related organic phosphates per gallon. In 1953 this material was applied with the May codling moth spray at the rate of 2.5 pounds of total actives per acre. At harvest, which occurred during the latter part of September, the treated plots were nearly free of aphids. It was obvious that commercial control of the aphid could be obtained with a dosage of less than 2.5 pounds of total actives per acre.

In 1954 the work with this insecticide was expanded. The most extensive tests were conducted at Linden, which is located in the northern San Joaquin Valley. Here schradan was applied at the rate of 1.5, 2.0 and 2.5 pounds per acre of total actives. Each treatment was replicated twice, and the plots consisted of 80 trees or approximately 4.5 acres each. The aphicide was incorporated with the codling moth spray and was applied on May 5 and 6 with a high capacity Speed Sprayer in 200 gallons of water per acre.

Excellent control of the walnut aphid was obtained for the entire season. Long after harvest the aphid population in the schradan treatments remained at an extremely low level. The trees held their foliage later into the fall than those which received other aphid control programs. With the latter treatments high aphid populations were encountered by mid-September.

At Linden the early season infestation of the walnut aphid in 1955 was extremely heavy. With the exception of the schradan treatments, destructive populations developed in all the plots treated in 1954. Two aphid surveys were made in the experimental orchard. The first of these was conducted on April 16 and the second on May 4, approximately 1 week before the 1955 treatments were applied. The results obtained which are expressed as the average number of aphids encountered on the next to the terminal leaflet are given in table 1. It should be noted that very few aphids were found in the schradan-treated plots, and that the population in these showed some relation to the dosage applied. It was lowest in the 2.5-pound treatment and highest where 1.5 pounds was applied. The trees in the schradan treatments were much more thrifty and vigorous than those that received other aphicides. The leaves were a rich green, heavier, considerably larger, and presented a marked contrast to those of other treatments which showed much evidence of aphid infestation. On many of the latter honeydew had accumulated on the tips of the leaflets in sufficient amount to causes tip burn.

The single schradan treatments resulted in excellent aphid suppression for a full year. The treatments applied in early May 1954 carried over until May of 1955. The absence of aphids in 1955 was apparently due to the excellent control obtained in

[1] Accepted for publication August 15, 1955.

Table 1.—Infestation of the walnut aphid in the spring of 1955 in plots that were treated in May 1954.

TREATMENTS AND POUNDS PER ACRE	AVERAGE NUMBER OF APHIDS ON:				
	April 16	April 22	May 4	May 18	May 25
Linden[a]					
Schradan (total actives)					
2.5	0.02	—	0.15	—	—
2.0	0.16	—	0.40	—	—
1.5	0.50	—	1.50	—	—
Systox (actual)					
1.0	12.7	—	30.4	—	—
0.75	22.4	—	34.9	—	—
0.50	19.8	—	37.5	—	—
0.25	10.2	—	35.0	—	—
All treatments except Systox and schradan[b]	23.6	—	42.8	—	—
San Jose[c]					
Orchard A					
schradan (total actives) 1.7	—	0.04	—	2.24	—
Systox (actual) 0.75	—	1.13	—	11.6	—
Orchard B					
schradan (total actives) 2.5	—	0.01	—	0.17	1.04
Systox (actual) 0.75	—	0.65	—	2.85	9.5

[a] Treated May 4 to 7, 1954.
[b] Average of parathion, malathion, BHC, and 14% nicotine dry concentrate treatments.
[c] Treated May 20, 1954.

1954 and not the result of a carry over of the residual action of schradan. The reduction of the aphid population was so complete during 1954 that practically no sexual forms were produced, and thus few overwintering eggs were laid. As a result the plots remained nearly free of aphids in the early spring of 1955 until the small developing population was reinforced by migrating winged individuals from surrounding plots. Because the stem mothers produced from overwintering eggs are wingless, no migration of any extent to the schradan plots could occur until their progeny reached maturity which was close to the middle of April. Following the May 4 survey the aphid population in the schradan plots began to increase rather rapidly and even in the 2.5-pound treatment by May 14, the average number of individuals per leaflet had risen to 7.2.

Results similar to those obtained at Linden were also encountered at San Jose, California (Table 1). The difference between the schradan treated plots and those that received other control programs was marked. However, because the general aphid infestation in 1955 was much less severe than that encountered at Linden the visible difference in the trees and foliage was not outstanding. At San Jose stem mothers were observed in very limited numbers indicating that few eggs were laid in the schradan plots during the fall of 1954.

The marked suppressing action of schradan on the walnut aphid has made possible a study of the full adverse influence exerted by this insect. It is possible that factors other than the walnut aphid are involved, but at present there appears to be nothing definite to support this theory. Besides the walnut aphid the schradan treatments at the above dosages exerted a residual controlling action against the crawlers of the frosted scale, *Lecanium pruinosum* Coq. and were effective against the Pacific spider mite, *Tetranychus pacificus* McG., but not the European red mite, *Metatetranychus ulmi* (Koch).

For effective suppression of the walnut aphid, schradan must be thoroughly applied. This precaution can not be over emphasized. Also, it should be applied before the walnut foliage becomes too mature.

Although schradan has been released for use on walnut by regulatory authorities in California, the future use of this insecticide is dependent upon whatever legislation is enacted regarding the permitted residue.

Control of Flower Thrips on Blackberries[1]

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The flower thrips, *Frankliniella tritici* (Fitch), occurs in abundance on a wide variety of plants in many of the Southeastern States (Watts 1936). This species has been observed in large numbers on cultivated blackberries (Youngberry) in Alabama. Quaintance, 1898, reported that thrips injury to blackberries resulted in incomplete fertilization and inferior fruits. The extent of thrips damage to fully developed fruit is not known; however, infested fruit is less attractive and may be condemned by the Food and Drug Administration. An experiment was begun in 1954 to determine the effect of certain insecticides on flower thrips on blackberries.

PROCEDURE.—Field experiments were conducted at the Chilton Area Horticulture Substation, Clanton, Ala., involving eight insecticidal treatments and an untreated check. The insecticidal treatments consisted of both one and two applications of parathion, malathion, TEPP, and nicotine sulfate sprays. Spray materials were applied to plants to the point of run-off with a power sprayer equipped with a hand gun. The first application was made 5 days before the first picking. Plots receiving two applications were sprayed again 7 days later. Plot size was one row of blackberries 25 feet long. Rows were spaced 12 feet apart. All treatments were replicated four times and randomized.

The effectiveness of treatments was measured by removing and counting the number of live thrips on samples of 25 ripe berries picked at random from each plot. Each sample was immersed in a NaCl solution (approximately 1 teaspoonful of salt in 500 ml. of water) to float the thrips and facilitate counting. The infestation counts were made at 2- to 4-day intervals throughout the picking season of approximately 3 weeks.

Additional samples of berries were taken from plots receiving two applications of parathion and malathion for residue determinations. These samples and samples from untreated plots were picked 4 days after the second application, packed in dry ice, and shipped by air express to the Stamford Research Laboratories of the American Cyanamid Company, Stamford, Conn., for residue analysis.

RESULTS.—Parathion and malathion treatments gave highly significant control of flower thrips throughout the season (Table 1). A slightly higher degree of control was obtained in plots receiving two applications of these compounds, but the differences were not significant. The thrips infestation in plots receiving only one application of parathion or malathion was still significantly lower than that of the untreated plots when the berry harvest was completed 25 days after treatment. Parathion was slightly more effective than malathion in reducing thrips populations, but again the difference was not significant. Although TEPP was somewhat effective in reducing the thrips infestation, the rate and spray schedule used in this experiment did not give adequate control. No control was obtained in plots treated with nicotine sulfate.

Results of the parathion and malathion residue determinations showed that not more than 0.5 p.p.m. of these materials was found on the blackberries.

SUMMARY.—Replicated field experiments were conducted in 1954 to test the effectiveness of parathion, malathion, TEPP, and nicotine sulfate against the flower thrips, *Frankliniella tritici* (Fitch), on blackberries (Youngberry). Parathion and malathion gave highly significant control. Nicotine sulfate and TEPP failed to give adequate control.

Parathion and malathion residues on berries picked 4 days after the second application did not exceed 0.5 p.p.m.

[1] Accepted for publication August 23, 1955.

Table 1.—Thrips populations on blackberries following certain insecticidal treatments, Clanton, Alabama, 1954.

Treatment[a] and Date of Application	Pints per 100 Gal.	Average No. of Thrips per 25 Berries on Dates Indicated[b]							
		5/14	5/17	5/19	5/21	5/24	5/28	5/31	6/4
Check	—	38.0	26.8	121.6	86.0	51.8	24.4	59.6	86.6
25% Parathion—5/10	1.0	0.0	2.8	6.6	8.0	7.8	4.0	7.3	13.8
25% Parathion—5/10, 5/17	1.0	0.0	1.0	0.3	0.8	1.3	1.3	1.8	12.0
50% Malathion—5/10	1.5	0.5	8.3	9.3	21.3	13.5	8.8	15.8	19.0
50% Malathion—5/10, 5/17	1.5	0.3	9.8	0.5	1.8	2.0	1.5	2.5	15.8
43% TEPP—5/10	0.25	9.3	58.5	130.5	87.0	29.8	28.8	58.5	60.3
43% TEPP—5/10, 5/17	0.25	21.5	26.0	20.5	28.5	23.0	20.0	49.0	51.8
40% Nicotine sulfate—5/10	1.5	32.0	54.3	84.5	68.5	45.8	21.3	61.8	93.3
40% Nicotine sulfate—5/10, 5/17	1.5	39.0	30.3	75.5	72.3	43.5	31.5	92.0	70.5
L.S.D. at 5% level	—	29.10	27.2	29.7	28.1	14.8	10.9	26.8	27.2
L.S.D. at 1% level	—	None	36.8	40.3	38.1	20.0	14.8	36.3	36.9

[a] Parathion and malathion concentrates were emulsifiable; TEPP and nicotine sulfate were miscible with water.
[b] Mean of four replications.

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The Effect of Wood Moisture Content on the Emergence of Southern Lyctus Beetle[1, 2]

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The rearing of large numbers of an insect species for studies dealing with its life history and control is frequently a difficult, time-consuming task. This was found to be true in the case of the southern lyctus beetle in studies conducted at the Agricultural Research Center, Beltsville, Maryland, several years ago. In an effort to overcome some of the difficulties, an exploratory test was conducted to determine the effect of an increase in moisture content on emergence of adults from heavily infested wood.

Samples of half-round 12-inch pieces of red oak, white oak, and hickory were selected. This wood had been initially infested about 6 months prior to the test and there was a partial emergence of beetles 3 months later. However, it was still very heavily infested when the test was started. Each sample was cut into two 6-inch pieces. The moisture content of the one set of pieces was increased by placing them in a horizontally positioned glass cylinder. Moisture was introduced by partially covering each end with moist paper towels which were in contact with a reservoir of water on the top side of the cylinder. No free water was allowed to collect in the cylinder. Cheesecloth was placed over both ends of the cylinder to keep parasites out and to insure a circulation of air over the wood. The corresponding set of 6-inch pieces, whose moisture content was not increased, was placed in an identical cylinder without the moist towels. In general the moisture content of all the wood at the start of the test was 9 per cent. Within 2 months the moisture content of the one set had increased to 12 per cent while the corresponding set had dropped to 8 per cent. Thus the difference in moisture content between the two sets was 4 per cent. The moisture content was calculated on the basis of change in weight of the wood. An electric moisture meter was used to check some of the moisture content calculation.

When emergence was complete, it was found that 600 more beetles had emerged from the set with the higher moisture content; putting it on percentage basis, around 34 per cent more beetles emerged from the wood of higher moisture content. This increase occurred in each of the 17 pieces used in the test, as illustrated in table 1. Figure 1 illustrates beetle emergence patterns for the high and low moisture contents. It is interesting to note that increase in moisture content did not accelerate emergence as expected. Previous exploratory tests—in which samples of red oak limbwood were quickly seasoned to moisture contents of 0–40 per cent, subjected to beetle attack, and then lowered to 12-per cent moisture—showed that beetles emerged several weeks earlier from the high-moisture-content wood.

Table 1.—Effect of an increase in moisture content of wood on the emergence of the southern *Lyctus* beetle.

Sample	Total Beetles Emerging	
	Moisture Content, 12%	Moisture Content, 8%
1	74	64
2	143	92
3	88	73
4	127	112
5	185	127
6	200	160
7	150	109
8	181	101
9	130	84
10	124	108
11	149	118
12	158	106
13	117	67
14	61	52
15	134	127
16	189	124
17	166	126
Total	2376	1750

The results of this test were applied to considerable advantage in rearing large populations of Lyctus adults used in numerous studies at the Agricultural Research Center at Beltsville. It was

[1] *Lyctus planicollis* (Lec.).
[2] Accepted for publication September 14, 1955.

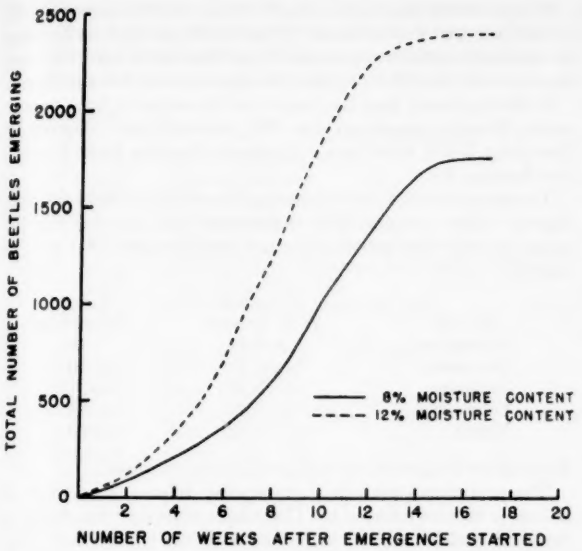

FIG. 1.—Emergence of *Lyctus planicollis* from 17 matched pieces of red oak limbwood with two different moisture contents as the only variables.

found that by moving the rearing area to a greenhouse where moisture content of wood could be maintained at 15 to 18 per cent the supply of beetles was approximately doubled.

Additional Leafhopper Vectors of Phony Peach[1]

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Four species of leafhoppers have been reported as experimental vectors of phony peach (Turner 1949), a virosis in which the virus itself is confined to the woody cylinder of its host plant (Hutchins 1939). The four incriminated species—*Homalodisca triquetra* (Fab.), *Oncometopia undata* (Fab.), *Cuerna costalis* (Fab.), and *Graphocephala versuta* (Say)—are members of the subfamily Tettigellinae, all of which feed in part on stems of plants, drawing their sustenance from the xylem. This fact suggests that ability to transmit phony peach depends on feeding habits, and that any member of the Tettigellinae that will feed on peach or plum is capable of transmitting the virus. The presumption is strengthened by the circumstance that Pierce's disease of grapes, the only other reported virosis in which the virus is xylem-limited, is also transmitted by Tettigellinae, transmission having been obtained with 20 species of this subfamily (Frietag *et al.* 1952).

In recent experiments two additional species of Tettigellinae have transmitted phony peach—*Draeculacephala* sp. and *Homalodisca insolita* (Walker).

The transmission tests with *Draeculacephala* sp. included both *portola* Ball and *balli* Van Duz. Unfortunately, the successful vector cannot be specifically determined. Only females were available for examination at the close of the successful test, and in this genus specific identification is based on male characters.

Draeculacephala sp. is not an efficient vector. In an experiment with 7 lots of insects caged serially on 2 to 6 trees per series, only one positive case of transmission occurred. Following the virus-acquisition period on the source tree, the successful lot was caged seriatum on 6 trees. The fourth tree became infected. The first exposure provided a latent period of only 12 days, but the second and third provided possible latent periods of 20 and 33 days, much longer than other vectors require to accomplish transmission. The successful exposure involved 5 individuals, 2 of which died on this test tree. Failure of the remaining 3 to infect the fifth and sixth trees of the series may indicate that these insects did not pick up the virus during their acquisition-feeding period—in fact, the low percentage of transmission for the entire experiment may stem from such an inefficacy of this species. On the other hand, failure of the successful vectors to infect the first three trees in the series suggests inefficiency in introducing the virus into a new host. Whatever the particular cause may be, the entire picture suggests that this species of *Draeculacephala* is so thoroughly conditioned to feeding on grasses that it has lost most of its ability to feed from the xylem of woody plants, such as peach, even though individuals may subsist for considerable periods when caged on this host.

Homalodisca insolita, on the other hand, appears to be as efficient an experimental vector of phony peach as any of the previously incriminated species, including those that are important natural vectors (*H. triquetra* and *O. undata*). In tests with 33 lots of 2 to 19 insects each, 14 lots transmitted the disease. This group efficiency of 42 per cent is higher than the average for any other species that has been tested.

Initially virus-free males and females of *insolita* transmitted the disease to peach from infected peach and from infected plum. Although no tests were made with regard to the latent period in this insect, in two tests transmission was achieved under conditions that permitted a latent period of not more than 10 and 11 days. In four tests groups of insects infected two trees in succession, no longer serializations being attempted. Transmission was not secured through the agency of single insects, but in one case it did follow inoculation by two insects.

The marked efficiency of *insolita* as a vector of phony peach is of particular interest because this species is not a native of the area in which the disease occurs. Until 1950 the species appears to have been collected only in Mexico, Arizona, New Mexico, and western Texas. During that year two specimens were taken on sticky-board traps at Fort Valley, Ga. Subsequent trapping and surveys indicate that *insolita* moved eastward during the late forties and has now become generally established in the Gulf Coast States, at least throughout the Coastal Plain. In the Southeast the insect is primarily a grass feeder. Indeed, its eggs have been found only on Johnson grass (*Sorghum halepense*) and Texas millet (*Panicum texanum*). However, a few adults have been observed feeding on peach twigs. Although *insolita* does not show promise of becoming an important natural vector of phony peach, it is probable that members of the species occasionally act as agents of dissemination.

Implication of *Draeculacephala* sp. and *Homalodisca insolita* as experimental vectors of phony peach adds further support to the hypothesis that any member of the subfamily Tettigellinae can act as a vector. The vector-efficiency rating of a particular species appears to be dependent on its feeding habits and not necessarily on its natural habitat or usual choice of host plants. None of the six species known to be capable of transmitting the disease, including the two important natural vectors, feed consistently, or even primarily, on twigs and branches of woody plants throughout the year. This fact emphasizes the importance of preventing the introduction of the disease into any new area where sharpshooters have any degree of natural association with peach trees.

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Mortality Studies on Hibernating Boll Weevils[1]

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Cage studies on the hibernation and winter survival of the boll weevil, *Anthonomus grandis* Boh., have been conducted at Florence, South Carolina, and other locations in the Cotton Belt over a period of many years. Fenton & Dunnam (1929) found that the average survival for the four-year period 1922–26 was 3.27 per cent. Later, Bondy & Rainwater (1942) found that survival in woods trash was consistently higher than survival in either Spanish moss or corn stalks, but that only a small percentage of weevils survived even the mildest winters. Similar experiments conducted at Tallulah, Louisiana, have shown winter survival to be low (Gaines 1943, 1953). These and other studies show survival rates for the complete hibernation period, but apparently no study has been made to determine the mortality at various periods during hibernation.

In the fall of 1954 two cage experiments with field-collected boll weevils were initiated at Florence to determine at what period during the winter the greatest mortality of hibernating boll weevils occurred.

In experiment 1 pyramid-type cages, constructed of wood and screen wire with removable tops and an open base area of 9 square feet, were placed over a natural layer of surface trash in the edge of a woods. The surface trash, consisting of leaf mold and fallen leaves from broadleaf deciduous trees, was approximately 3 to 4 inches deep. Twenty-five cages were arranged in a Latin-square design, and on October 19 and 20 a total of 200 field-collected weevils were placed in each cage.

Five cages each were examined at different times between December 1 and April 18 to determine the mortality. All the surface trash within each cage and about ½ inch of the top soil were placed in a canvas bag and taken to the laboratory for examination. The trash was processed through a shaker machine used in the regular examinations of surface woods trash for hibernating boll weevils, and then placed on a heating table, and records made of the live boll weevils found.

On December 1 the mortality was found to be 53.5 per cent, indicating a high kill before cold weather set in. This is believed to be due to the fact that many of the weevils were not ready for hibernation when placed in the cages. Handling, of course, would account for some loss; however, the procedure used in placing them in the cages should have kept this loss at a minimum. There was no significant increase in mortality between December 1 and January 4, when the mortality had reached 61.2 per cent. There was, however, a highly significant increase on January 31, when a 73.3 per cent mortality was found. On March 16 the mortality had increased slightly to 78.4 per cent, and by April 18 it had reached 81.9 per cent. The increase from January 31 to April 18 was significant.

In experiment 2 cylindrical screen-wire cages 7½ inches in diameter and 12 inches high and open at each end were placed over surface trash at the edge of the same woods as in experiment 1. The cages were pressed into the soil about 1 inch, and extra soil was placed around them for anchorage. Forty-eight cages were arranged in a randomized-block design, and on November 1 five field-collected weevils were placed in each cage and cheesecloth covers placed over the cages.

Six cages each were examined on different dates to determine the mortality. At each date the surface trash and top soil in the cages were placed on a heating table and live weevils counted.

The mortality increased from 23.3 per cent on November 17 to 56.6 per cent on November 30 and 63.3 per cent on January 14—a highly significant increase. From then until April 18, when the mortality was 73.3 per cent, the increase was not significant.

It will be noted that the trend was the same in both experiments. In each experiment over 50% mortality had occurred by December 1 and there was a significant increase from January 4 to January 31.

Temperatures at Florence during the winter of 1954–55 were slightly below normal. The departures from normal for the mean monthly and lowest minimum temperatures (°F.) were as follows:

Month	*Departure from Normal*	*Lowest Minimum*
November	−2.9	25
December	−2.9	20
January	−3.5	21
February	−2.3	14
March	+1.2	19

Rainfall for the period was 2.59 inches below normal.

The procedures used in these studies differed from those in the other studies referred to. The winter mortality was found to be lower and is believed to be closer to the natural mortality. Additional studies (unpublished) indicate that an even more accurate estimate may be obtained by using hibernating boll weevils collected from surface woods trash instead of field-collected weevils.

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[1] Accepted for publication September 27, 1955.

[2] In cooperation with the South Carolina Agricultural Experiment Station.

Tests with Repellents Against the American Dog Tick[1]

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Granett & French (1950) reported dibutyl adipate to be very effective against the American dog tick, *Dermacentor variabilis* (Say). Cole & Lloyd (1951) also obtained excellent protection against this species with dibutyl adipate, and with two general-purpose repellent mixtures designated M-1960 and M-2040.

Additional field tests with these and other repellents as clothing treatments for protection against this tick were conducted during June and July 1952 at Montauk, Long Island, N. Y. The repellent mixtures used were modifications of M-1960, selected on the basis of their effectiveness against various biting arthropods. The names of the individual repellents and the formulas

[1] Accepted for publication September 1, 1955. This work was conducted at the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine under funds allotted by the Department of the Army.

[2] Now with the Plant Pest Control Branch, Agricultural Research Service.

[3] The authors are grateful to Carroll N. Smith and W. C. McDuffie for advice in planning the tests, and to Philip Granett and his student assistants of Rutgers University for their cooperation

of the mixtures are given below. All the mixtures contained 10 per cent of Tween 80 (sorbitan monooleate, polyoxyalkylene derivative) as an emulsifier. With the exception of M-2059, they contained 30 per cent of each of the other ingredients.

Orlando No.	*Individual Repellents*
523	Benzyl benzoate
671	Dibutyl adipate
2484	*N*-Butylacetanilide
3341	*N*-Isopropylacetanilide
3775	2-Butyl-2-ethyl-1,3-propanediol
4145	*N*-Butyl-4-cyclohexene-1,2-dicarboximide
5524	*N*-Propylacetanilide
7126	Undecenoic (undecylenic) acid
	Active Ingredients of Mixtures
M-1960	3775, 523, 2484
M-2006	3775, 523, 5524
M-2033	3775, 523, 3341
M-2038	3775, 4145, 2484
M-2039	3775, 7126, 2484
M-2040	4145, 7126, 2484
M-2059	M-1960 (99%), lindane (1%)
M-2060	3775, 523, 671
M-2061	3775, 671, 2484

Army fatigue trousers of herringbone twill were impregnated with emulsions of the repellents. Dibutyl adipate was applied at 2 grams and the mixtures at 3.6 grams per square foot. Three trousers were treated with each material, and each garment was tested three to seven times at intervals of a few days. Men wearing the treated trousers walked slowly along roadsides well infested with adult ticks, brushing against the vegetation and allowing the ticks to crawl onto the trousers, usually below the knee. Ticks that remained on the trousers and crawled as high as the bottom of the patch pockets were removed and counted. As the first person in line usually picked up the most ticks, the order in line was rotated every 5 minutes. One member of the group wore untreated trousers as a check in each test. Exposure periods ranged from 15 to 65 minutes, until at least 25 ticks had been counted on the check.

Table 1.—Comparative effectiveness of repellents as clothing treatments against the American dog tick. (3 replications.)

Repellent No.	Per Cent Repellency After Indicated Days of Aging					
	7–9	13–14	15–17	20–22	27–28	Average, 7–17
671	88	82	89	31	63	86
M-1960[a]	90	96	92	67	90	93
M-2006	61	73	94	26	—	76
M-2033	37	80	79	27	—	65
M-2038	63	68	86	46	—	72
M-2059	85	86	96	59	93	89
M-2060	73	75	72	44	—	73
M-2061	82	89	88	70	96	86
M-2039[b]	88	86	50	—	—	75
M-2040[b]	96	88	65	—	—	83

[a] 93% after 33 days in 1 replication and 79% after 36 days in 2 replications.
[b] Conducted concurrently with the last 3 tests of M-1960.

The results are given in table 1.

M-1960 was slightly more effective than the other materials, with an average repellency of 93 per cent for the first three tests. M-2059, M-2061, and dibutyl adipate were next in effectiveness with average repellencies of 86 to 89 per cent for the same period.

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Effect of *Bacillus thuringiensis* on *Trogoderma granarium*[1]

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The problem of controlling stored grain pests is very acute all over the world. Various methods of control by fumigation and treatment with insecticides have been evolved which are very helpful but at the same time have their limitations. Entomologists in various countries have tried to find new methods of controlling stored grain pests by means of bacteria which are not pathogenic to human beings but are pathogenic to various insect pests.

Jacobs (1950) studied the possibility of controlling the Mediterranean flour moth, *Ephestia kühniella* Zell., with the bacterium *Bacillus thuringiensis* Berliner, and hinted at its partial success. Steinhaus & Bell (1953) tried the same bacteria against the granary weevil, *Sitophilus granarius* (L.) and remarked "further tests on the possible application of *Bacillus thuringiensis* Ber. in the control of stored grain pests would be worthwhile." The authors in accordance with this view carried out a series of experiments on the effect of *Bacillus thuringiensis* against different stored grain pests common in India. *Trogoderma granaria* Everts which is a serious pest of wheat and commonly known as khapra beetle was taken first.

Materials and Methods.—The beetles were collected from the godown of central Jail, Alipur from infested wheat and a culture was maintained in the laboratory. A pure culture of *Bacillus thuringiensis* was received from Dr. E. A. Steinhaus, Insect Pathologist, Berkeley, California, U.S.A. The culture was very kindly maintained by Mr. H. N. Basu at the laboratory of the Bengal Immunity Co., Calcutta, as the facilities for maintaining the bacterial culture were not available in our laboratories. Mr. Basu supplied us the bacteria in powdered form as requested.

The tests were carried out in small petri dishes of 6″ diameter. The experiment was carried out in six replications. In the first test the stored grain used was wheat, 25 grams of sound and uninfected wheat grains were placed in each petri dish and 50 mgm. of the bacterial powder was thoroughly mixed with the grains. In order to allow some time for the bacterial spores to establish themselves on the grains, the grubs of the insects were released 24 hours after mixing the powder with the grain. Only grubs of the insect were used in the infectivity tests. One hundred grubs were released in each dish. In order to have the grubs approximately of the same age, lengths of their body and their breadth at the mesothorax were regularly noted and only those grubs having a length of 5 mm. and breadth of 2 mm. at mesothorax were selected for our experiment. Observations were made at intervals of 15 days.

During the experiment average temperature ranged between 82 and 65 ± 2.5° F. and average relative humidity was 71.7%.

Results.—From the observations made during the experiments, incorporated in table 1, it may be seen that there was no appreciable difference between the rate of mortality in the treated and untreated dishes. The rate of mortality is shown in table 1. In the first fortnight the mortality was 0.1 per cent in both treated and untreated grain.

In the second and third fortnights the mortality in the experimental dishes was, however, 0.3 per cent and 0.6 per cent, respectively, but there was no mortality in the control dishes. The

[1] Accepted for publication June 25, 1955.

Table 1.—Infectivity tests in the grubs of *Trogoderma granaria* with *Bacillus thuringiensis*. 1954–55.

Date of Observation	Stage of Insects During Period of Test	Results with Treated Insects[a]		Results with the Control Insects[a]	
		Mortality	Percentage Mortality	Mortality	Percentage Mortality
Aug. 31	Living grubs	97.83		97.83	
	Dead grubs	0.17	0.17	0.17	0.17
	Pupal stage	2.00		2.00	
Sept. 15	Living grubs	95.17		94.83	
	Dead grubs	0.33	0.33	0.00	nil
	Pupal stage	2.00		3.00	
Sept. 30	Living grubs	92.83		93.17	
	Dead grubs	0.67	0.67	0.00	nil
	Pupal stage	2.00		1.67	
Oct. 15	Living grubs	91.17		90.00	
	Dead grubs	0.17	0.17	0.00	nil
	Pupal stage	1.50		3.17	
Oct. 30	Living grubs	89.33		86.67	
	Dead grubs	0.17	0.17	0.00	nil
	Pupal stage	1.67		3.33	
Nov. 14	Living grubs	86.67		84.67	
	Dead grubs	0.00	nil	0.00	nil
	Pupal stage	2.67		2.00	
Nov. 29	Living grubs	84.17		82.00	
	Dead grubs	0.17	0.17	0.00	nil
	Pupal stage	2.33		2.67	
Dec. 14	Living grubs	82.17		79.67	
	Dead grubs	0.17	0.17	0.00	nil
	Pupal stage	2.00		2.33	
Dec. 29	Living grubs	79.67		77.00	
	Dead grubs	0.00	nil	0.00	nil
	Pupal stage	2.50		2.67	
Jan. 1	Living grubs	76.67		74.00	
	Dead grubs	0.00	nil	0.00	nil
	Pupal stage	3.00		3.00	

[a] Average of six replications of 100 grubs each.

mortality in the experimental dishes in the 4th, 5th, 6th, 7th, 8th, 9th, and 10th fortnights only varied from 0 per cent to 0.1 per cent. In the control dishes, however, there was no mortality. Regarding the appearance of the dead grubs it was observed that, when dead, they became shrunken in appearance with the integument quite intact. There was also no putrefying odor from the dead grubs.

DISCUSSION.—The experiment was carried out for a period of 150 days. The results obtained clearly show that there was some mortality of the insects fed on the grain treated with bacteria, whereas there was practically no mortality of the insects which fed on the untreated grain. But the difference between the rate of mortality in the treated and control dishes was too slight to be of any practical value.

The reasons for such insignificant results may be due to the habit of the grubs of this insect. As a rule, the grubs attack first the embryo of the grain and then bore into and feed on the kernel. They come out only when the kernel is completely devoured. In most cases they leave the major portion of the surface of the grain intact. The authors feel that such insignificant effect of the bacteria on the mortality of the grubs may be due to this habit. The mortality of insects according to the presumption of Steinhaus & Bell (1953) is due to the ingestion of the spores by the insects while eating through the outer seed coat. It appears then that the spores ingested by the grubs of *Trogoderma granaria* while boring into the kernel of the grain is quite insufficient for death and consequently the rate of mortality is very low as is obvious from table 1. The authors, however, agree with the view of other workers in this kind of research, that there is a possibility of using *Bacillus thuringiensis* for controlling stored grain insects and that further trials with different insects and different quantities of spore material might be helpful in establishing some definite result of infinite importance.

ACKNOWLEDGMENTS.—The authors wish to thank Dr. S. N. Banerjee, Head of the Section of Entomology, West Bengal for help in carrying out the experiment. They also wish to express their indebtedness to Dr. E. A. Steinhaus, Insect Pathologist, U.S.A. for kindly supplying the bacterial culture, without which it would not have been possible to carry out the investigations. Sincere thanks are also offered to Mr. H. N. Basu for maintaining the culture for us.

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Effect of Streptomycin on Some Stored Grain Insects[1]

R. K. DE, *Entomological Laboratory, State Agricultural Research Institute, Calcutta, India*

The problem of controlling stored grain pests has been one of foremost importance throughout the world. The methods of control with insecticides which have been in vogue for a long time, have many limitations. New light has been thrown on the problem by the use of antibiotics for controlling stored grain insects. Steinhaus & Bell (1953) carried out some interesting experiments and showed the effects of different antibiotics like streptomycin, terramycin, penicillin, etc., against stored grain insects like *Sitophilous oryzae* (L.), *Tribolium confusum* Duv., etc. Steinhaus hinted about the possibilities of using these antibiotics for the control of stored grain pests, but doubted the practicability of the method.

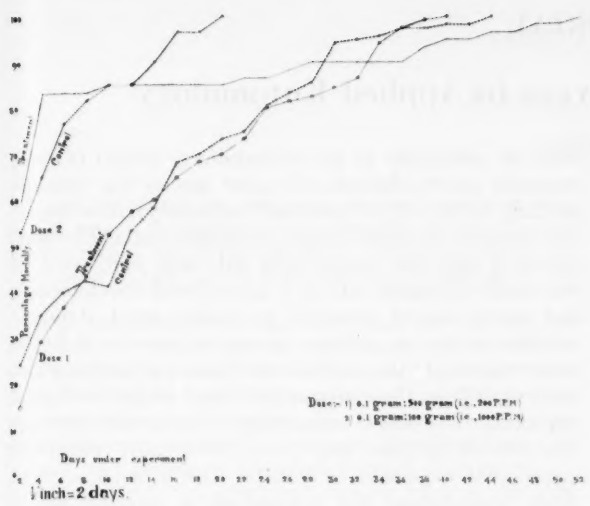
The studies reported in this paper were undertaken to find out whether very low doses of the antibiotics which were expected to be economical (considering the prevailing price of the antibiotics in this country) were strong enough to be toxic to the insects.

MATERIAL AND METHODS.—The stored grains used in these experiments were rice (husked paddy) and wheat. Only two pests were taken in the first instance, viz., *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Hbst.) the red flour beetle. Different stages of these insects were collected from local sources of infested grains and cultures were maintained in the laboratory. Only adult insects were used in the tests. The tests were carried out in petri dishes of 6″ diameter. The grains were treated with streptomycin (Dihydro-Streptomycin) of Chas. Pfizer & Co. of U.S.A. The experiment was done in six replications both in control and treated dishes. Streptomycin was added to the grain in a powdered form. Twenty adult insects were then released in each dish. Adults from the same culture maintained in the laboratory were released at the same time in control dishes. The petri dishes were examined on alternate days to determine the mortality of insects. Observations were simultaneously made on the control dishes.

For the experiment with *Sitophilus oryzae* the grain used was rice and two doses of streptomycin were taken, viz, 0.1 gm. of streptomycin per 100 gm. of grain (i.e. 1:1000 parts) and 0.1 gm. of streptomycin per 500 gm. of grain (i.e. 1:5000 parts). The temperature in the laboratory during the experiments was 85.1 ± 6.8° F. and average relative humidity was 92%.

RESULTS.—The results obtained, however, did not show any detrimental effect of the antibiotic on the population of the insects. From graph No. 1 it can be seen that there was no appreciable difference between the rate of mortality of *Sitophilus oryzae* released in rice grains treated with streptomycin at either

[1] Accepted for publication August 24, 1955.

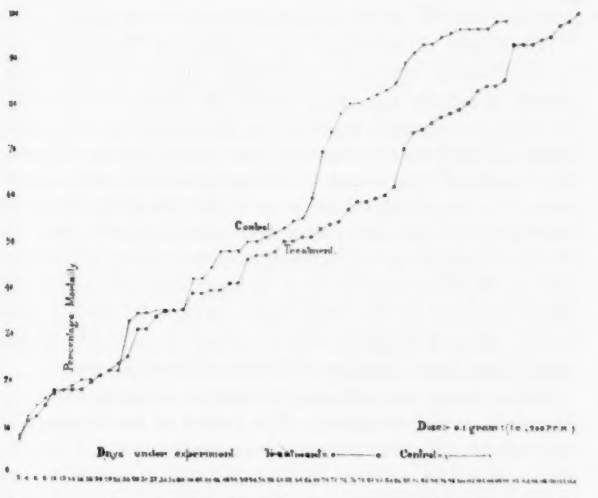


GRAPH 1.—Showing the effect of treatment of rice grains with Streptomycin on the mortality of *Sitophilous oryzae* Linn.

dosage and those released in control dishes. On the other hand 100 per cent mortality was obtained much earlier in the control dishes than in treated dishes.

In the case of *Tribolium castaneum*, similarly there was no appreciable difference in the rate of mortality of the adults in treated and control dishes. On the other hand 100 per cent mortality was obtained in the control dishes much earlier than the treated dishes, as can be seen from graph No. 2.

DISCUSSION.—The methods for control of insect pests of stored grains generally involves treatment with insecticides or fumigation. Difficulties are faced when the question of treating flour, rice, etc. with insecticides arises as it is not practicable to treat flour directly with any insecticide by mixing for obvious reasons. Only method applicable is by fumigation. Absorption of fumigants in grains and lack of facilities for fumigation in many places also are great hindrances to this method of control. These handicaps led entomologists to hunt for some new and easy method of control of stored grain pests. Their investigations threw light on an important fact which obviously has far-reaching effects. They found that many of the insects found in stored grains harbor



GRAPH 2.—Showing the effect of treatment of wheat grains with streptomycin on the mortality of *Tribolium castaneum* Herb. One-half inch=2 days.

living micro-organisms within certain tissue cells. Steinhaus & Bell (1953) stated, "The role of these intracellular symbiotes, as they are called, is known in a few species of insects. In some insects, such as the drug store beetle and cockroaches it appears that the symbiotes produce essential vitamins and possibly hormone substances. In the case of stored grain insects, the physiological relationship between the symbiotes and the insects has not been determined. However, since the symbiotes in these insects appear to be in as intimate a relationship as in most other symbiote-bearing insects, there is reason to believe they may provide their hosts with metabolic essentials of one sort or another." Steinhaus and Bell on the basis of such an assumption decided to investigate the possibility of killing or preventing the reproduction of stored grain pests by depriving them of their symbiotes through the use of antibiotics.

Experiments of Brues & Dunn (1945) and Glaser (1946) on cockroaches showed that these insects can be freed of their symbiotes by means of antibiotics. These workers found that, the administration of sub-toxic doses of penicillin greatly reduce the number of intracellular symbiotes in the bacteriocytes of the cockroach and that this decrease in nature is accompanied by a deficiency of certain unidentified constituents essential to the health of the insect. Recently Musgrave & Miller (1951) reported that when the granary weevil and the rice weevil were fed terramycin-treated grains both species showed some degree of mortality over that in untreated controls.

Steinhaus & Bell (1953) observed that "in the course of making preliminary tests as to the feasibility of depriving stored grain beetles of their intracellular bacterial symbiotes by means of antibiotics, it was found that these drugs are toxic to most of the insects tested. Relatively large doses (0.3 to 0.5 gms. per 14 grams of grain) of aureomycin, bacitracin, chloromycetin, penicillin G, polymixin B, streptomycin and terramycin killed 100 per cent of the granary and rice weevils tested within 30 to 60 days."

It is quite obvious from the above that there is at least some possibility of using antibiotics for the control of insect pests of stored grains. But one important factor which is vital for such investigations is that of the dose to be used, as the success of the method is dependent on establishing a dose of the antibiotic which would be effective against the pest and at the same time would be economical.

From our results, it can be concluded that a dose of streptomycin in the ratio of 1 part to 1000 parts or 5000 parts of grain is not effective and does not produce any discernible effect on the mortality of *Sitophilus oryzae* and *Tribolium castaneum* in their adult stages.

ACKNOWLEDGMENTS.—My thanks are due to Dr. S. N. Banerjee, Head of the Section of Entomology, Department of Agriculture, West Bengal for facilities for work and helpful suggestions. Thanks are also due to Mr. S. Sen for helping in taking observations. I am indebted to Dr. E. A. Steinhaus, Insect Pathologist, University of California, for encouraging me in taking up the work and on the basis of whose work these investigtaions were carried out.

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EDITORIAL

The Relation of Faunistic Surveys to Applied Entomology

Faunistic insect surveys are designed to determine and understand the total insect fauna of a given region. Because of the large number of species involved (about 20,000 for a moderate-sized state), because of the time and diligence required to find the localized or rarer species, and because of the incompletely known taxonomy of many groups, extensive faunistic surveys of insects have been qualitative rather than quantitative. In addition to clarifying the taxonomic arrangement of groups under study, the most important function of such surveys is to gain a better idea of the place occupied by various species in the ecological organization of the area. New knowledge concerning host relationships, distribution patterns, seasonal adjustments, and other items contributes to such an orientation.

These faunistic surveys unearth several different kinds of information which are helpful to programs in applied entomology. The first kind deals with a clarification of identification problems concerning the accurate separation of economic and non-economic species. We know of many cases in which economic species resemble one or more non-economic species to such a striking degree that only minute details of structure can be used as reliable criteria for their identification, as in the case of *Empoasca fabae* and its allies. In large part due to the wealth of material made available by intensive field collecting, surveys of local areas are bringing to light more and more instances in which this phenomenon occurs. Dissemination and use of this knowledge is vital to the accuracy of insect pest surveys and to the correct cataloguing of information concerning the bionomics and control of definite insect species.

Several kinds of biological information arising from these surveys are especially useful to applied entomology as it relates to cultivated crops. It is being discovered, for instance, that certain economic species have a much wider range of wild hosts than was previously known. The identity of all such hosts would give a basis for evaluating the importance of natural population reservoirs in the epidemiology of economic species of insects, or diseases transmitted by insects.

Another item correlated with host discoveries is becoming increasingly important. Certain native species, to date poorly known taxonomically and biologically, appear to be transferring locally to cultivated crops. In some cases, such as the June beetle recently established on soy beans, the insect threatens to become a serious economic menace. In other cases we have as yet little evidence as to the possible future importance of such potential pests. A working knowledge of the host preferences, bionomics, and the seasonal and geographic distribution patterns of these insects at the time they were first encountered on a crop could easily advance research progress by a year or more. Securing such information is part and parcel of a faunistic survey program.

Species of insects are dynamic, changing entities, evolving now as they have in the past. It is almost certain that man-made conditions are contributing and will continue to contribute to the evolutionary tempo of some economic insects. Introduced insect species may transfer partially to new native hosts and conversely native species may transfer partially to new economic plants. The areal extent of different hosts, both wild and cultivated, is constantly changing with new agricultural developments and insect control practices inevitably exert stringent selective action on various species of insects. A better understanding of the possible new strains of insects which may result from these interacting forces might be of great importance to applied entomology. Some serious work on this problem has been undertaken, principally concerning insecticidal resistance in insects. The broader aspects, when undertaken, will necessitate a coordination of efforts by the faunistic survey worker, the geneticist, the physiologist, and the applied worker.

Discussions along these latter lines may seem a bit fantastic, but there is one thought we should keep in mind. The aim of applied entomology is avowedly to control the abundance and distribution of noxious and beneficial insects. Is it not conceivable that, to accomplish this aim, we will be faced ultimately with the problem of controlling the genetic change or evolution of many insects? Perhaps the answer has already been given in the artificial development of DDT-resistant strains of codling moth parasites for liberation in Canadian orchards.

Let us put these thoughts another way. The cultivated crops and their insects form an ecological sphere which intermingles geographically with another ecological sphere, the native or wild biota. These two systems are relatively separate and non-mixing, but there is a constant, though perhaps small, interchange of biotic elements between them. In the case of the insects this interchange has a bearing on the ultimate control problem. In contributing to an understanding of this mixing process, faunistic surveys should provide basic data.

Forest and range cropping is taking on the aspects of environmental control so steadily that preferred crop species in forests and range may soon occupy practically the same ecological position as do crops in cultivated areas. In such an eventuality there would occur between the "cropped" species and the plant species in unmanaged areas the same interchange of insect elements that we find between the cultivated and uncultivated areas. In the forest and range situations, however, most of the crop species might be native ones or their derivatives closely allied to many of the uncropped species. In such a situation a more extensive mixing of insect elements would occur than would be expected with cultivated crops.

Since almost every family of insects contains elements of potential importance to this aspect of environmental control, it will take many taxonomists many years to accomplish the work needed for providing complete and accurate faunistic surveys in North America alone.

HERBERT H. ROSS,
Illinois Natural History Survey, Urbana

OBITUARIES

Ernest Ralph Sasscer

1883-1955

A veteran entomologist who was largely instrumental in building our present national defenses against alien insect and plant disease enemies was lost to the official Washington scene with the passing on July 7, 1955 of Ernest Ralph Sasscer at the age of 71.

His accomplishments during a half-century career in the U. S. Department of Agriculture are encompassed in the citation accompanying the distinguished service award he received from the Department in 1953: "For inspirational leadership in planning, organizing, and directing the Department's activities against the entry and spread of plant pests, thereby adding to the Department's prestige at home and abroad." This highest attainable Departmental award was probably his most cherished recognition.

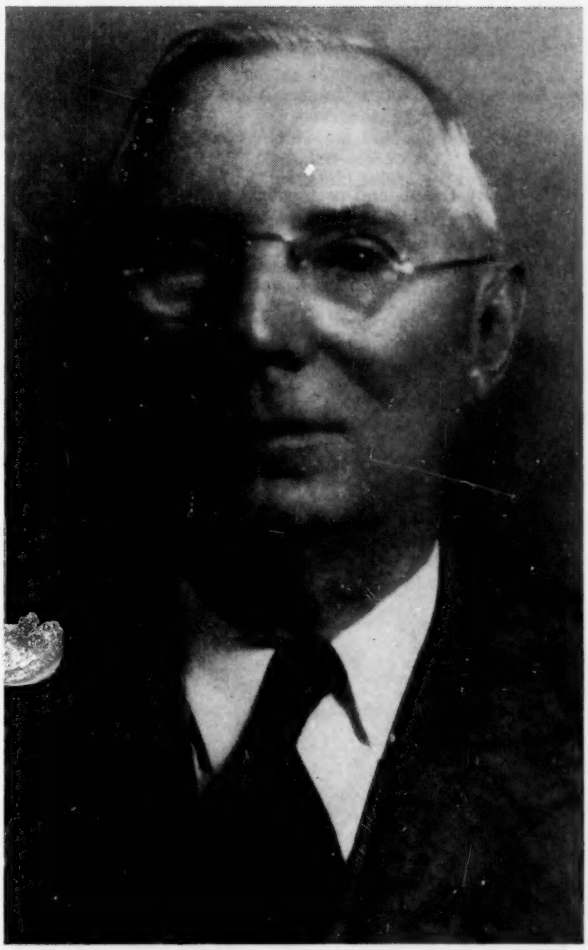
His early interests and specialties are well illustrated by the topics he chose for his presidential addresses to the Entomological Society of Washington during his successive terms in 1918 and 1919. His 1918 address was on "Hydrocyanic acid gas and its use in control of insects"; in 1919, "Coccid observations." Over the years his grasp of entomologic problems was broadened to circle the globe. This was apparent in his historic analysis of international plant quarantine activities in his absorbing 1939 presidential address to the American Association of Economic Entomologists, "Undesirable Insect Aliens."

His scale insect investigations led to important developmental work in vacuum fumigation as a means of destroying insects on imported plants and plant products. This pioneer work expanded into modern plant quarantine fumigation procedures. He early recognized the danger to American agriculture of foreign plant pests arriving in imported plant materials. As a result he led in arousing an international consciousness of the need for world-wide plant quarantine protection. He traveled extensively in Europe, having studied plant quarantine operations in England, France, Belgium, Holland, Germany, Switzerland, and Italy, as well as Canada, Mexico, and Cuba. This international service was recognized by Queen Juliana of the Netherlands on November 9, 1953, when she conferred on him the Officer's Cross of the Order of the House of Orange-Nassau. In 1954, King Baudouin of Belgium named him an officer of the Order of the Crown. He was also instrumental in transforming the function of the Federal plant quarantine inspector from a police-like role to that of a highly trained professional specialist.

He was the author or coauthor of scores of publications appearing as government bulletins and reports or as articles in professional journals. His career was interestingly sketched in a feature article "They Fight an Endless Invasion" which appeared in the Saturday Evening Post on October 10, 1953.

Born in Waldorf, Md., October 23, 1883, Mr. Sasscer received his secondary school education at McDonough Institute, La-Plata, Md. He obtained his B.S. degree at the Maryland Agricultural College (now the University of Maryland) in 1904 and his M.S. there in 1913. He was employed during the summer of 1904 as a nursery inspector by the Maryland Experiment Station. On October 21, 1904 he was appointed a scientific aid in the old U. S. Bureau of Entomology, where he specialized in the taxonomy of the scale insects. Thereafter his entire professional career was spent in the U. S. Department of Agriculture.

Following his original appointment in 1904, Mr. Sasscer quickly advanced to positions of increasing responsibility. He became a scientific assistant in 1906, chief inspector of the Federal Horticultural Board in 1912, and entomologist and executive officer of the Board in 1924. In 1928 he was appointed head entomologist in charge of the Division of Foreign Plant Quarantines, Bureau of Entomology and Plant Quarantine, in which office he continued until his retirement in October 1953.



Ernest Ralph Sasscer

A congenial companion, he had a keen sense of humor and was skilled at repartee. He enlivened his talks with apt anecdotes. He was impatient with the red tape in which the promulgation of plant quarantines became enmeshed in the past decade.

In 1951, Mr. Sasscer was a member of the United States delegation to the conference called by the Food and Agricultural Organization of the United Nations at The Hague. The conference worked out the final draft of the International Plant Protection Convention, a treaty now in effect.

In addition to the affiliations already mentioned, Mr. Sasscer was a member of the former Entomological Society of America, Biological Society of Washington, Washington Academy of Sciences, American Association for the Advancement of Science (fellow), Sigma Xi, and other scientific and professional organizations. He was also a member of the Cosmos Club, Columbia Country Club, and the Masonic Order.

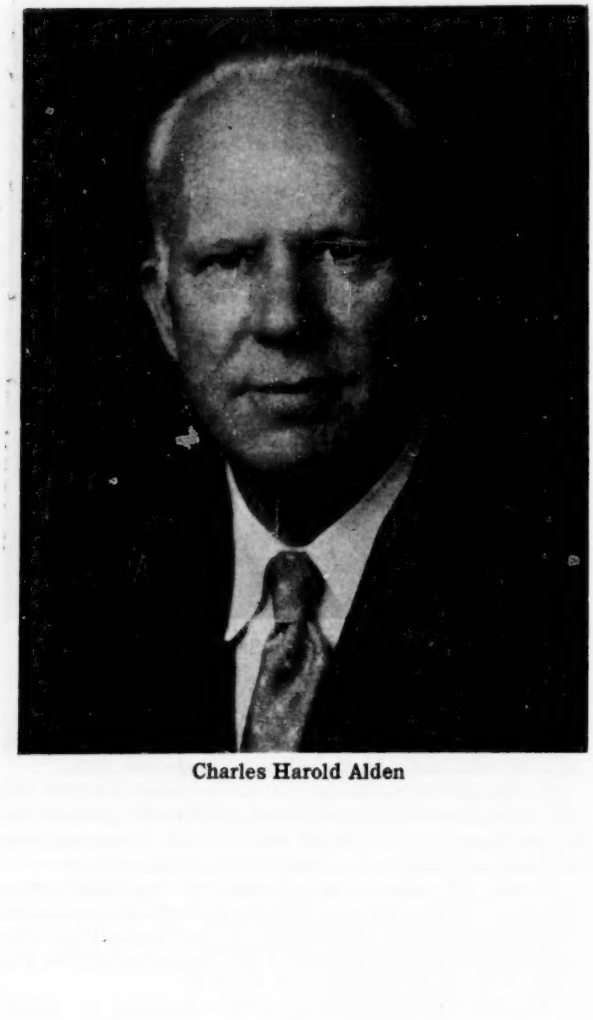
He is survived by his widow, the former Mary Kelley Lynch of Washington, D. C., whom he married in 1913, and a daughter, Mrs. Elizabeth Anne Rumsey of Franklin, Mich.

Following his retirement, Mr. Sasscer traveled extensively. He passed away suddenly as the result of a heart attack at a hotel in Minneapolis, Minn., where he and Mrs. Sasscer had stopped for the night en route home from a cross-country automobile trip. His body was cremated in Minneapolis and his ashes returned for private interment in Glenwood Cemetery, Washington. A memorial service in his honor was held at a funeral parlor in Bethesda, Md., on July 12.

RALPH W. SHERMAN,
Plant Quarantine Branch,
Agricultural Research Service,
U. S. Department of Agriculture

Charles Harold Alden
1894-1955

The many friends and professional acquaintances of Charles H. Alden were saddened by the recent death of this oustanding Director of the Georgia Department of Entomology. Mr. Alden died at his home in Decatur, Georgia on September 18, 1955.



Charles Harold Alden

C. H. Alden was born on February 6, 1894 in Rockdale, Mass In 1915 he received the Bachelor of Science degree from Massachusetts State College. After graduation he was appointed by the Massachusetts Department of Agriculture as a nursery inspector. In 1917 Mr. Alden received an appointment with the U. S. Department of Agriculture as a special agent. After serving with the army during World War I he returned to the U. S. Bureau of Entomology as an Assistant Entomologist. Work in this capacity brought him to Georgia where in 1919 he accepted a position with the Georgia Board of Entomology as Entomologist in charge of the Fruit Pest and Parasite Laboratory. In 1942 he was appointed Director of the Georgia Department of Entomology and served in this capacity until his death.

Mr. Alden was a charter member of the Georgia Entomological Society which was organized in 1937 and served as its first president in 1937, repeating as president in 1940. He was a long time member of the American Association of Economic Entomologists and served as chairman of the Cotton States Branch of this Association. He was also a member of the Southern Plant Board, serving this organization in various capacities including the chairmanship and as a representative to the National Plant Board. He was also a member of numerous other professional and civic groups.

Mr. Alden's services to the people of Georgia in the field of Entomology will long be remembered. Shortly before his untimely death he was presented a plaque from the Georgia Entomological Society, commemorating his 35 years of outstanding service to the people of Georgia. His years of tireless work furthering the cause of State-Federal relationships in their various cooperative quarantine and control endeavors has not only benefited the people of Georgia but of the entire nation. Another recent recognition given him was by the American Camellia Society for his outstanding work toward the eradication of camellia flower blight.

Surviving Mr. Alden is his wife, Mrs. Ivis Snow Alden and two sons, John C. Alden of Fort Valley and Robert M. Alden of Decatur.

His outstanding work, his warm and sincere friendship will be forever cherished by his many friends and associates.

W. E. BLASINGAME

INDEX, VOLUME 48, 1955

A-42, for control of squash bug, 613
AC-528, for control of spotted alfalfa aphid, 673
Acalymma
  cornuta, 38
  trivittata, 38
Acalypteratae, 649
Acanthocinus obsoletus, 164
Acanthoscelides obtectus, 757
Acaricides
  for control of apple mites, 24
  in insect vector research, 749
Acaricides, relative effectiveness of, against
  citrus bud mite, 376
  citrus flat mite, 377
  citrus red mite, 376
  citrus rust mite, 377
  Yuma mite, 377
Aceratagallia
  sanguinolenta, 449
  uhleri, 339
Aceria
  sheldoni, 376
  tulipae, 486, 612
Achaetoneura archippivora, 39
Acheta assimilus, 449
Achytas incertus, 711
Aconti
  aprica, 619
  dacia, 293, 599
  lactipennis-tetragona groups, 599
  terminimaculata, 599
Acrylonitrile fumigation, effect of on, walnut husk fly, 752
Actia interrupta, 459
Acutaspis albopicta, 615
Acyrthosiphum destructor, 751
Adelphocoris, 543
  lineolatus, 449, 718
  rapidus, 156, 449
Aedes
  aegypti, 49, 215, 741
  alaskaensis, 67
  communis, 67
  excrucians, 67
  fitchii, 67
  punctor, 67
  sollicitans, 741
  stimulans, 67
  taeniorhynchus, 741
Aedes, effect of clothing color on,
  communis, 130
  fitchii, 130
  pionips, 130
  punctor, 130
Aeolothrips fasicatus, 450
Aetalion
  quadratum, 615
  sp., 615
Agallian leafhoppers, 342
Agalliopsis sp., 615
Agathis agalis, 684
Ageneotettix deorum, 328
Agonoderus comma, tests with insecticide-treated corn seed against, 555
Agrotis
  malefida, 619, 740
  ypsilon, 155, 740
Alabama argillacea, 175, 293, 740
Aldrin, effect of
  on seed-treated soybeans, 539
  soil treatments on strawberries, 700
Aldrin
  reaction of wireworms to, 438
  tests with, against house flies, 414
Aldrin, for control of
  army cutworm, 227
  alfalfa plant bug, 720
  bean weevil, 757
  black vine weevil, 208
  blow fly infestations, 182
  cabbage maggot, 470
  chicken lice, 142
  chinch bug, 243
  clover root borer, 191
  clover root curculio, 185
  corn earworm, 716
  corn flea beetle, 559
  Douglas-fir beetle, 503
  Egyptian alfalfa weevil, 300
  European brown snail, 698
  European chafer, 384
  garden centipede, 247
  garden webworm, 224
  grasshopper nymphs, 721
  house flies, 273
  meadow spittlebug, 191
  mountain pine beetle, 502
  onion thrips, 310
  pea leaf miner, 580
  plum curculio, 734
  potato leafhopper, 720
  seed-corn maggot, 688
  serpentine leaf miner, 596
  soil insects of corn, 255
  squash bug, 254, 613
  sugarcane termites, 537
  strawberry root weevil, 208
  sweetpotato weevil, 486, 646
  tarnished plant bug, 720
  tomato fruitworm, 519
  wireworms, 14
Aldrin, toxicity of to
  chinch bug, 241
  German cockroach, 572, 577
  house fly larvae, 109, 732
  Opius oophilus, 75
  oriental fruit fly larvae, 75
  Pseudocneorhinus bifasciatus, 628
  squash bug, 250
  sweetpotato weevil, 616
Aleurocanthus
  spiniferus, 681
  woglumi, 414, 682
Aleurodicinae, 614
Aleurodicus dugesii, 614
Aleurodothrips fasciapennis, 434
Aleuroglyphus ovatus, 754
Alfalfa
  effect of leafhopper on growth, 323
  pollination in Manitoba, 543
Allethrin, effectiveness against
  common malarial mosquito, 51
  corn earworm, 716
  house flies, 50
  northern house mosquito, 51
  yellow-fever mosquito. 51
Allethrin in house fly sprays, 407
Allethrin, toxicity of to
  American cockroach, 747
  German cockroach, 747
  house fly, 747
Allothrombium sp., 447
Amblyomma
  americanum, 139, 223, 295, 338, 396, 400, 499
  maculatum, 396, 400
  sp., 450
Am. Cyanamid 12008, for control of
  apple aphid, 697
  garden centipede, 247
  spotted alfalfa aphid, 672
Am. Cyanamid 12009, for control of garden centipede, 247
Am. Cyanamid 12008, for treating wheat seed, 486
Am. Cyanamid 12009, for treating wheat seed, 486
Am. Cyanamid 4124, for control of
  alfalfa plant bug, 722
  flies in dairy barns, 307
  grasshopper nymphs, 722
  potato leafhopper, 722
  short-nosed cattle louse, 566
  tarnished plant bug, 722
Am. Cyanamid 4124, toxicity of, to house fly, 610, 680
Am. Cyanamid 4389, for control of apple aphid, 696
Amitus hesperidum, 682
Amphelasma cavum cavum, 38
Amphimallon, 712
Amphimallon majalis, control of, with granulated insecticides, 384
Amphorophora
  nervata, 87
  sonchi, 87
Anacampsis innocuella, 622
Anagrus
  armatus nigriceps, 476
  epos, 476
Anaphoidea pullicrura, 559
Anasa tristis, 250, 613, 711
Anastrepha ludens, 133, 414, 461, 657
Anaulacomera denticauda, 37
Andrector atrofasciatus, 38
Andricus californicus, 340
Aneristus youngi, 446
Anisoptera, 663
Anomala
  nitidula, 38
  undulata, 38
Anopheles atroparvus, infested with *Vorticella microstoma*, 215
Anopheles
  quadrimaculatus, 49, 665, 741
  sp., 461
Anotia invalida, 38
Anthonomous grandis, 95, 293, 422, 604, 772
Antibiotics, toxicity of to German cockroach, 217
Anuraphis
  maidi-radicis, 256
  tulipae, 108
Aonidiella
  aurantii, 444, 584
  citrina, 446, 584
Apanteles
  angaleti, 627
  diatreae, 41, 42
  epinotiae, 622
Aphaereta auripes, 42
Aphelenchoides sp., 478
Aphelenchulus sp., 478
Aphis
  abbreviata, 624

bakeri, 87
gossypii, 293, 350, 530
maidis, 38
medicaginis, 188
pomi, 695
Aphids, survival of after injection, 751
Aphodius
pardalis, new turf pest, 476
spp., 155, 256
Aphycus
"C" (China), 447
eriocci, 446
flavus, 446
enteolus, 447
maculipes, 446
sp., 446
Aphycus (*Pseudococcobius*) *terryi*, 711
Aphytis
"A," 445
chrysomphali, 444, 585
mytilaspidis, 445
proclia, 445
"X," 446
Apis mellifera, 477, 484, 514, 522, 544
Apis mellifera
effect of on cantaloup yields, 327
rearing larvae *in vitro*, 43
Aplanobacter stewarti, 555
Aplomya caesar, 712
Apple spray programs, complexities in, 304
Aramite, effect of diluents on, 762
Aramite, for control of
brown wheat mite, 157
citrus flat mite, 377
mites on apple, 329
strawberry aphid, 582
two-spotted spider mite, 178
Yuma mite, 377
Aramite, toxicity of to
citrus red mite, 215
two-spotted spider mite, 85, 215
Archips rosaceana, 450
Argyrotaenia velutinana, biology of, 51
Aroclor, 153, 482
Artemita bellardii, 41
Artona catoxantha, 714
Asemum moestum, 164
Aspidiotus
ancylus, 279
destructor, 615
oxycoccus, 223
Aspidiotiphagus
citrinus, 434, 444
lounsburyi, 434
spp., 444
Attractants for Japanese beetle, 703
Autographa spp., 155
Avocado fruits
respiratory response of to fumigation against fruit flies, 369
vapor heat sterilization of, 133
Azelia spp., 650

Bacillus
pluton, 43
thuringiensis, 675, 773
Bacterium eurydice, 44
Baits, for control of
blow flies, 563
European brown snail, 698
filbertworm, 340
house fly, 308, 528, 563, 623, 642
oriental fruit fly, 315
Bathyplectes curculionis, 288
Bayer L 13/59, for control of
blow flies, 564
cattle grubs, 201
flies in dairy barns, 308
goat lice, 567
house flies, 565, 732
mosquitoes in rice fields, 665
short-nosed cattle louse, 566
Bayer L 13/59
residual effect with chlorinated terphenyls, 483
toxicity of to German cockroach, 557
toxicology of homologs and derivatives of, 430
Bayer L 13/59, systemic effect of, in rabbits, on
bed bug, 140
lone star tick, 140
Bayer 16259, toxicity of to cotton insects, 294
Bayer 17147
effect of on boll weevil, 604
for control of pink bollworm, 294
toxicity of to cotton insects, 294
Bayer 18/178, systemic effect of, in rabbits, on
bed bug, 140
lone star tick, 140
Bayer 21/116, systemic effect of, in rabbits, on
bed bug, 139
lone star tick, 139
Bayer 21/199, for control of
cattle grubs, 201
goat lice, 567
house fly larvae, 732
short-nosed cattle louse, 566
Bayer 21/199, systemic effect of, in rabbits, on
bed bug, 140
lone star tick, 140
Bayer 21/200, for control of
cattle grubs, 201
goat lice, 567
Bdellonyssus sylviarum, 605
Beauveria globulifera on alfalfa weevil, 288
Bees, honey
decline and growth of colonies, 723
sperm distribution in the spermathecae of multiple-mated queens, 522
usefulness in tripping alfalfa, 544
Bemisia sp., 614
BHC, effect of,
as a larvacide against house flies, 271, 732
low dosages on California red scale, 586
on beneficial insects, 477
on seed-treated soybeans, 539
BHC, effect of soil-treated black locust on
Daphnia pulex, 761
Enchenopa binotata, 761
BHC, for control of
alfalfa plant bug, 722
ambrosia beetles, 164
armyworm, 261
bark beetles, 164
bean weevil, 757
black vine weevil, 208
blow fly infestations, 182
boll weevil, 95
brown wheat mite, 157
clover root borer, 190
corn flea beetle, 559
European brown snail, 698
grasshopper nymphs, 722
meadow spittlebug, 190, 594
onion thrips, 310
peach catfacing insects, 635
peach tree borer, 736
pink bollworm, 95
potato leaf hopper, 722
roundheaded borers, 164
strawberry root weevil, 208
sugarcane termites, 535
tarnished plant bug, 722
walnut aphid, 505
weevils, 164
wireworms, 554
BHC, for protection of pine logs from boring insects, 163
Biological control, interrelations of with taxonomy, 710
Biological control of
citrus insects and mites, 432
Epilachna philippinensis, 758
European corn borer in Guam, 683
orange spiny whitefly in Guam, 681
scale insects on Texas citrus, 444
Biology of
Ambylomma americanum, 295
Anacampsis innocuella, 622
Chaetocnema spp., 555
Eotetranychus uncatus, 47
Pseudocneorhinus bifasciatus, 628
tabanids, 709
Tabanus abactor, 618
Tabanus equalis, 618
Therioaphis maculata in Israel, 668
Birdsfoot trefoil, insects, 447
Bis(*p*-chlorophenyl) ethynyl carbinol, for control of strawberry aphid, 582
Blaberus giganteus, 480
Black flies
larval control of in Guatemala, 379
larval control of, 274
Blattella
germanica, 106, 109, 572, 576, 747, 753
vaga, 59
Blattella germanica
relation of water loss to egg hatching, 57
toxicity of antibiotics to, 217
Blattella, oöthecae of
germanica, 34
orientalis, 33
vaga, 35
Blissus
leucopterus, 240, 242
leucopterus insularis, 37
Blow flies, poison baits for control of, 563
Blueberry-stunt
leafhopper vectors of, 1
virus transmitted by *Scaphytopius magdalensis*, 8
Bombus
fervidus, 547
rufocinctus, 547
ternarius, 547
terricola, 547
vagans, 547
Bordeaux mixture, for control of potato aphid, 686
Bothriocera tinealis, 37
Bovicola
caprae, 567
limbatus, 567
Brachymeria
carinatifrons, 758
ovata, 622
Brachypterolus pulicarius, 450
Brachyrhinus
ovatus, 207
sulcatus, 207
Bracon
brevicornis, 626
gelechiae, 627
kirkpatricki, 627
mellitor, 627
nigrorufum, 627
vulgaris, 627

Brevicoryne brassicae, 87, 188
Brevipalpus lewisi, 377
Brochymena quadripustulata, 473
Bruchus pisorum, 693
Bulan, for control of
alfalfa plant bug, 722
corn earworm, 716
grasshopper nymphs, 722
potato leafhopper, 722
tarnished plant bug, 722
Butoxypolypropylene glycol, 167
(see Crag fly repellent)
for control of flies in dairy barns, 307

Calcium arsenate, for control of sweetpotato weevil, 644
Calendra parvula on orchard grass, 335
Calliephialties dimorphus, 627
Calliphoridae, 649
Calliphora
mortica, 649
terrae-novae, 649
vomitoria, 649
Callitroga
hominivorax, 459, 462, 467
macellaria, 28, 182, 466, 563
Calomycterus setarius, 292
Calopsectrini, 663
Camponotus herculeanus pennsylvanicus, 753
Canisters found satisfactory
gas-mask, 458
respirator, 458
Capitophorus
braggi, 87
fragaefolii, 581
xanthii, 87
Capnodium sp., 608
Captan, effect of seed-treatment
on corn, 552
on soybeans, 542
Captan seed treatments, 688
Carbowax, a carrier of systemic insecticides, 486
Carneocephala dyeri, 37, 615
Carpocapsa pomonella, 156, 505, 598
Casidara dugesii, 615
Castolus plagioticollis, 37
Castor beans, injurious insects on, 110
Catfacing insects, control of, 635
Catolethrus longulus, 39
Cattle sprayers, automatic, for fly control, 386
Celerio lineata, 740
Centeter cinerea, 713
Ceratitis capitata, 316
Cerococcus sp., 615
Ceroplastes floridensis, 615
Chaetocnema
confinis, 555
denticulata, 555
minuta, 555
pulicaria, 555
Chaoborinae, 663
Cheletogenes
ornatus, 447
wellsi, 447
Chelonis
annulipes, 91, 611, 684
blackburni, 627
pectinophorae, 627
Chemicals, zonal dispersion in soils,
aldrin, 61
DDT, 61
dieldrin, 61
lindane, 61
Chilocorus
cacti, 445
confusor, 446
sp., 55
stigma, 434
Chloranil seed treatments, 688
Chlordane
differential susceptibility of to American cockroach, 131
effect of soil treatments on strawberries, 702
tests with, against house flies, 272, 414
Chlordane, for control of
armyworm, 261
army cutworm, 227
alfalfa plant bug, 720
bean weevil, 757
black vine weevil, 208
blow fly infestations, 182
cherry fruit fly, 576
chicken lice, 142
chinch bug, 243
clover root curculio, 185
corn earworm, 198
corn flea beetle, 559
corn leafhopper in Hawaii, 205
Cyrtophinus mundulus, 206
Egyptian alfalfa weevil, 298
European brown snail, 698
European chafer, 384
garden centipede, 247
grasshopper nymphs, 720
green June beetle, 621
Ips interpunctus, 502
lone star tick, 224
mole cricket, 645
mountain pine beetle, 502
pea leaf miner, 581
Pityogenes carinulatus, 502
Polistes exclamans, 161
potato leafhopper, 720
seed-corn maggot, 688
squash bug, 613
strawberry root weevil, 208
sweetpotato weevil, 645
tarnished plant bug, 720
tomato fruitworm, 520
white grubs, 645
wireworms, 12, 554, 645
Chlordane, toxicity of to
chinch bug, 241
German cockroaches, 572
house fly, 109, 610, 732
Opius oophilus, 75
oriental fruit fly larvae, 75
Pseudocneorhinus bifasciatus, 628
squash bug, 250
sweetpotato weevil, 616
Chlorobenzilate, for control of
brown wheat mite, 158
citrus bud mite, 376
citrus flat mite, 377
citrus red mite, 375
European red mite, 105
mites on apple, 329
strawberry aphid, 582
two-spotted spider mite, 178
Yuma mite, 375
Chlorobenzilate
not harmful to aphids and leafhoppers, 750
residues of, in lemon fruits, 372
Chlorotabanus crepuscularis, 609
Chlorthion, for control of
alfalfa plant bug, 722
apple aphid, 696
bed bugs, 753
blow flies, 564
boll weevil, 95
cattle grubs, 201
chicken body louse, 567
European brown snail, 698
flies, 307, 318
German cockroach, 753
goat lice, 567
grape mealybug, 102
grasshopper nymphs, 722
house flies, 528, 643
pink bollworm, 95
plum curculio, 735
potato leafhopper, 722
short-nosed cattle louse, 566
tarnished plant bug, 722
Chlorthion, for treating wheat seed, 486
Chlorthion, systemic effect of, in rabbits, on
beg bug, 140
lone star tick, 140
Chlorthion, toxicity of to house fly strains, 610
Cholinesterase, effect of insecticides on, 266
Chorinaeus sp., 622
Chorizagrotis
auxiliaris, 227
auxiliaris agrestis, 39
Chortoglyphus arcuatus, 754
Chromaphis juglandicola, 504, 768
Chrysobothris sp., 164
Chrysomphalus
aonidum, 432, 446
dictyospermi, 615
ficus, 615
Chrysopa
carnea, 670
lateralis, 436
sp., 607
vulgaris, 530
Chrysops, control of
carbonaria, 125
excitans, 125
frigida, 125
furcata, 125
mitis, 125
sordida, 125
Cimex lectularius, 139
Circulifer tenellus, 327, 341, 713
Citrus fruits, vapor heat sterilization of, 133
Clastoptera sp., 615
Cleistolophus similis, 39
Clivinia impressifrons, insecticide-treated corn seed against, 555
Clothing color, effect of on mosquito attack, 130
Coccinella
arcuata, 758
7-punctella, 670
11-punctella, 670
undecimpunctata, 530
Coccophagus
baldassarii, 54
eleaphilus, 54, 447
eritreaensis, 54
fraternus, 446
lecanii, 446
lycimnia, 446
nigritus, 54
sp., 447
Coccus
hesperidum, 53, 279, 446, 615
magniferae, 615
pseudomagnoliarum, 53
Cockroach oöthecae, water relations of, 33
Coecygominus aequalis, 53
Coelophora inaequalis, 758
Colaspis flavida, 256

Colaulon rectangularis, 193
Coleomegilla maculata, 614
Colladonus
geminatus, 588, 749
montanus, 749
Collaria oleosa, 37
Collops vittatus, 614
Collyria calcitrator, 711
Common names of insecticides, 112, 345
Comperiella bifasciata, 445, 587
Compound 923, for control of
brown wheat mite, 157
European red mite, 103
Compound
A-42 for control of European brown snail, 698
G-339 for control of European brown snail, 699
G-341 for control of European brown snail, 699
1269 for control of European brown snail, 699
2066 for control of European brown snail, 699
Compsilura concinnata, 711
Coniopteryx vicina, 436
Conoderus
amplicollis, 192
auritus, 193
aversus, 193
bellus, 192
lividus, 11, 192
perversus, 193
rudis, 192
sp., 256
vagus, 191
vespertinus, 191
Conotrachelus nenuphar, 390, 473, 635, 730, 734
Corn, insects on, in Guatemala, 36
Corn seed
beetles, 256
maggots, 256
Cosmolaelaps sp., 436
Cotinis nitida, 621
Coxiella burnetii, isolated from lone star tick, 396
CPR, for control of
alfalfa plant bug, 722
grasshopper nymphs, 722
potato leafhopper, 722
tarnished plant bug, 722
Crag Fly Repellent, for control of
biting flies, 387
Tabanus sulcifrons, 167
Crambus caliginosellus, 328
Crematogaster
arizonensis, 446
laeviuscula, 446
Cryolite, for control of
garden centipede, 247
sweetpotato weevil, 644
CS-728, for control of
alfalfa plant bug, 720
grasshopper nymphs, 721
plum curculio, 735
potato leafhopper, 720
tarnished plant bug, 720
tomato fruitworm, 520
Cuerna mexicana, 37
Culex
erraticus, 665
fatigans, 215
molestus, 216
pipiens, 49
Culiseta impatiens, 67
Cybocephalus sp., 445
Cyclethrin, for control of biting flies, 387
Cyclethrin in
house fly sprays, 407
livestock sprays against flies, 409
Cyclocephala, 256
2-Cyclohexyl-4, 6-dinitrophenyl acetate, toxicity of to
citrus red mite, 215
two-spotted spider mite, 215
Cylas formicarius elegantulus, 486, 615, 644
Cynomyopsis cadaverina, 649
Cyrtepistomus castaneus in Delaware, 289
Cyrtophinus mundulus, toxicity of insecticides to, 205

Dacus dorsalis, 75, 133, 311
Dalbulus (*Baldulus*) *maidis*, 37
Daphina pulex, 759, 760
Dasyneura vaccinii, 223
DDD, for control of
California red scale, 586
corn earworm, 198
garden webworm 224
DDT, effect of
low dosages on California red scale, 585
on serpentine leaf miner, 596
DDT, for control of
alfalfa plant bug, 720
army cutworm, 227
armyworm, 261
bean weevil, 757
black flies, 276
black vine weevil, 208
boll weevil, 95
cabbage maggot, 471
chicken body louse, 567
chinch bug, 243
codling moth, 305, 598
corn earworm, 198, 199, 225, 443, 716
corn flea beetle, 559
corn leafhopper in Hawaii, 205
Cyrtophinus mundulus, 206
deer flies, 127
Egyptian alfalfa weevil, 298
European brown snail, 698
European corn borer, 200
garden centipede, 247
gypsy moth, 172
goat lice, 567
grasshopper nymphs, 721
horse flies, 127, 270
Ips interpunctus, 502
Japanese beetle, 703
lygus bugs, 511
meadow spittlebug, 594
mountain pine beetle, 502
onion thrips, 310
peach catfacing insects, 635
peach tree borer, 736
pea leaf miner, 580
pine boring insects, 164
pink bollworm, 95, 295
Pityogenes carinulatus, 502
potato leafhopper, 720
short-nosed cattle louse, 566
spinach leaf miner, 581
spotted alfalfa aphid, 672
strawberry root weevil, 208
sugarcane termites, 534
sweetpotato weevil, 487
tarnished plant bug, 720
tomato fruitworm, 519
wireworms, 12
DDT-dehydrochlorinase as a factor in house fly resistance to DDT, 406
DDT-dieldrin, in HFA No. 1 oil, for control of
boll weevil, 423
bollworm, 423
DDT
differential susceptibility of American cockroach, 131
effect of beneficial insects, 477
per cent recovered from samples, 219
residues in fat of steers pastured on DDT-treated fields, 606
residues on tomatoes, 744
resistance of house fly to, 638, 736
resistance of codling moth to, 598
tolerance of lygus bugs to, 509
DDT, toxicity of to
chinch bug, 241
green peach aphid on peach, 333
house fly, 109, 111
Opius oophilus, 75
oriental fruit fly larvae, 75
Pseudocneorhinus bifasciatus, 628
squash bug, 250
sweetpotato weevil, 616
DDVP, for control of
house flies, 623
mosquitoes in rice fields, 665
Deer flies, control of, 330
Demeton (see also Systox)
Demeton, effect of soil-treated black locust on
Daphnia pulex, 761
Enchenopa binotata, 761
Demeton, for control of
apple aphid, 696
boll weevil, 95
brown wheat mite, 157
green June beetle, 621
hop aphid, 708
lygus bugs, 626
pea aphid, 193, 626
pea leaf miner, 580
pink bollworm, 95
spinach leaf miner, 581
strawberry aphid, 582
two-spotted spider mite, 583, 708
wireworms, 17
Demeton
for treating wheat seed, 486
residues on tomatoes, 744
Dendrobias mandibularis, 38
Dendroctonus, chemical control of
monticolae, 501
pseudotsugae, P^{32} in, 80
pseudotsugae, 501
valens, 164
Dermacenter variabilis, 396, 400, 772
Derostenus variipes, 597
Desert locust, cooperative control of, 392
Desmia funeralis, 155
Dexia ventralis, 712
Dexilla vacua, 712
Diabrotica
adelpha, 38
balteata, 38
lepida, 38
longicornis, 256
nigrofasciata, 38
porracea, 38
rufomaculata, 38
sexmaculata, 38
tibialis, 38
tricolor, 38
Diaryl-trifluoromethyl-carbinols as synergists for DDT, 638
Diaspis sp., 615
Diatraea
grandiosella, 40, 611
lineolata, 40
saccharalis, 40, 42
spp., 37, 38, 39, 41

Diaulinopsis callichroma, 597
Diazinon, effect of on seed-treated
corn, 553
soybeans, 540
Diazinon, for control of
alfalfa plant bug, 722
apple aphid, 697
blow fly infestations, 182
cherry fruit fly, 575
chicken body louse, 567
codling moth, 305, 598
European brown snail, 698
flies, 308, 318, 642
goat lice, 567
grape mealybug, 102
grasshopper nymphs, 722
hop aphid, 708
onion thrips, 311
potato leafhopper, 722
spotted alfalfa aphid, 673
short-nosed cattle louse, 566
tarnished plant bug, 722
two-spotted spider mite, 178, 708
Diazinon, systemic effect of, in rabbits, on bed bug, 139
lone star tick, 139
Diazinon
in traps against oriental fruit fly, 313
residual effect with chlorinated terphenyls, 483
tests against house flies, 488
toxicity of to German cockroach, 577
toxicity of to house fly, 610, 732
Dibrachys daphne, 607
Dicerca sp., 164
Dicrepidius
corvinus, 193
ramicornis, 193
Dieldrin
as a larvacide against house flies, 272
differential susceptibility of American cockroach, 131
reactions of wireworms to, 438
tests with, against house flies, 414
Dieldrin-DDT, in HFA No. 1 oil, for control of,
boll weevil, 423
bollworm, 423
Dieldrin, effect of
on beneficial insects, 477
soil treatment on strawberries, 700
seed-treated soybeans, 539
Dieldrin, for control of
alfalfa plant bug, 720
alfalfa weevil, 287
American cockroach, 753
army cutworm, 227
armyworm, 261
bean weevil, 757
bed bugs, 753
black vine weevil, 208
blow fly infestations, 182
boll weevil, 96
cattle grubs, 761
cherry fruit fly, 575
chicken lice, 142
chinch bug, 243
clover root curculio, 185
corn earworm, 715
deer flies, 127
European brown snail, 698
European chafer, 384
Egyptian alfalfa weevil, 299
German cockroach, 753
grasshopper nymphs, 721
house flies, 127
meadow spittlebug, 594
mountain pine beetle, 502
oriental cockroach, 753
plum curculio, 734
potato leafhopper, 720
onion thrips, 310
oriental fruit fly, 313
peach catfacing insects, 635
pea leaf miner, 580
Polistes exclamans, 162
root maggots, 471
seed-corn maggot, 688
serpentine leaf miner, 596
sheep ked control, 195
soil insects on corn, 257
squash bug, 250, 254
strawberry root weevil, 208
sugarcane termites, 537
sweetpotato weevil, 487
tarnished plant bug, 720
tomato fruitworm, 519
wireworms, 13
Dieldrin, toxicity of to
chinch bug, 241
German cockroach, 572, 577
house fly larvae, 732
Opius oophila, 75
oriental fruit fly larvae, 75
Pseudocneorhinus bifasciatus, 628
sweetpotato weevil, 616
Dikraneura carneola, 750
Dilan and synergists, effectiveness against house flies, 146
Dilan, for control of
alfalfa plant bug, 720
army cutworm, 227
cherry fruit fly, 575
codling moth, 598
corn earworm, 716
Egyptian alfalfa weevil, 299
grasshopper nymphs, 721
green June beetle, 621
potato leafhopper, 720
tarnished plant bug, 720
tomato fruitworm, 519
Dilan
residues on tomatoes, 744
toxicity of to house fly larvae, 732
Diluents, effect of on acaricides, 762
Dimmockia incongrua, 622
Dinitroanisole, toxicity of to body lice eggs, 765
Diphenyl for control of European brown snail, 699
Diphenyl ethane for control of European brown snail, 699
Diphenyl methane for control of European brown snail, 699
Diprion
hercyniae, 712
polytomum, 712
Disonycha sp., 39
Dispersion
of chemicals in soils, 61
of rice field mosquitoes, 30
studies on cherry fruit fly, 616
Diversinervus elegans, 55
DMC, for control of
brown wheat mite, 157
European red mite, 105
strawberry aphid, 582
DMC, toxicity of to two-spotted spider mite, 85
DN-111, effect of on seed-treated soybeans, 539
DN-289
for control of European red mite, 103
grape mealybug, 101
strawberry aphid, 582
Dormant oil, for control of European red mite, 104
Doru lineare, 37, 41
Dosage-mortality curves, adaptation of to machine calculation, 335
Draeculacephala
balli, 771
portola, 771
soluta, 37
sp., 615
Drapetes taeniolalus, 38
Drosophila
dispersion from pit privies, 19
melanogaster, 19
nigricuria, 41
radioactively tagged, 19
repleta, 19
sp., 467
Dysmicoccus sp., 615

Elachertus sp., 622
Empoasca
fabae, 285, 323, 449, 718, 776
solana, 110
Enchenopa binotata, 760
Endrin, for control of
alfalfa plant bug, 722
army cutworm, 227
armyworm, 261
bean weevil, 757
blow fly infestations, 182
boll weevil, 96
brown wheat mite, 157
chinch bug, 243
corn earworm, 225, 716
European brown snail, 698
garden centipede, 247
garden webworm, 224
grasshopper nymphs, 722
onion thrips, 311
pea leaf miner, 580
pink bollworm, 59
plum curculio, 735
potato leafhopper, 722
serpentine leaf miner, 596
soil insects on corn, 255
spotted alfalfa aphid, 672
strawberry aphid, 582
tarnished plant bug, 722
Endrin, toxicity of to
chinch bug, 241
German cockroach, 577
house fly, 109, 111, 414, 732
Pseudocneorhinus bifasciatus, 628
Opius oophilus, 75
oriental fruit fly larvae, 75
squash bug, 250
sweetpotato weevil, 616
Endrin, in HFA No. 1 oil, for control of
boll weevil, 423
bollworm, 423
Enopyga crista, 39
Entomology, its future, 491
Entomology, applied, relation of faunistic surveys to, 776
Entomophthora sp., 437
Eomenacanthus stramineus, 142, 567
Eotetranychus
sexmaculatus, 432
uncatus, 47
yumensis, 377
Ephestia kühniella, 109
Epicaerus capteillensis, 39
Epiglaca apiata, 223
Epilachna varivestis, 96, 187, 343
EPN, effect of on,
oriental fruit moth, 390
seed-treated soybeans, 539

EPN, for control of
black flies, 277
brown wheat mite, 158
cherry fruit fly, 575
codling moth, 305
garden centipede, 247
goat lice, 567
lesser peach tree borer, 736
pea leaf miner, 580
plum curculio, 734
potato aphid, 686
short-nosed cattle louse, 566
spinach leaf miner, 581
strawberry aphid, 582
two-spotted spider mite, 178
wireworms, 17
EPN, residues on tomatoes, 744
EPN, toxicity of to
house fly larvae, 732
squash bug, 250
sweetpotato weevil, 616
two-spotted spider mite, 85
Ephemeroptera, 663
Epilachna
philippinensis, 758
varivestis, 758
Equipment for
black fly larval control, 202
insect collector, mechanical, 478
magnetically suspended insect cage, 756
pressure injection of insecticides, 479
Eretmocerus serius, 682
Erythrogonia
jucunda, 37
laudata, 615
Erythroneura
dolosa, 750
plena, 750
Erythroneura variabilis, effect of malathion on eggs, 221
Estigmene acrea, 293, 740
Ethylene dibromide, effect of fumigation with on avocado fruits, 369
Ethylene dibromide, for control of
apple maggot, 484
cherry fruit fly, 617
corn earworm, 717
Douglas-fir beetle, 503
Ips interpunctus, 502
mountain pine beetle, 502
peach tree borer, 736
Pityongenes carinulatus, 502
Eulimneria sp., 683
Eumecosomyia nubila, 41
Eupelmella vesicularis, 450
Euphara caerulea, 41
Euphoria vestita, 38
Euscelus striatulus, 222
Euschistus
servus, 473
tristigmus, 473
variolarius, 499, 473
Eutetranychus banksi, 444
Eutettix tenellus, 713
Euxanthellus sp., 54
Euxesta
major, 41
obliquestriata, 41
schnusei, 41
sororcula, 41
stigmatias, 41, 442
Exeristes roborator, 627, 683
Exitianus exitiosus, 750
Exochomus floralis, 55
Exochus sp., 622
Exorista
larvarum, 712
mella, 712
Exterminator, Ladner's Parasite and Insect, systemic effect of, in rabbits, on
bed bug, 140
lone star tick, 140

Fannia
canicularis, 620
pusio, 620
spp., control of, 306, 650
Farinococcus olivacus, 615
Feltia
subgothica, 155
subterranea, 619, 740
Fieberiella florii, 588, 750
Flavor
effect of soil insecticides on strawberries, 700
evaluation of on malathion-treated lettuce, 151
Flies
filth of Alaska, 648
species and relative abundance collected from chicken manure, 620
Fly
breeding in animal carcasses, 181
control in dairy barns, 306
traps, sugar-baited, mode of action, 235
Food plants, effect of, on lesser migratory grasshopper, 119
Food and agriculture organization of UN, 393
Francilia alaskensis, 649
Frankliniella
occidentalis, 339
tritici, 293, 450, 767, 769
Fruit flies, effect of fumigation against on avocado fruits, 369
Fucellia spp., 650
Fumigation
effect of on diapause of, walnut husk fly, 752
ethylene dibromide tests against cherry fruit fly, 617
respiratory response of avocado fruits to, 369
Furethrin, for control of
American cockroach, 49
common malarial mosquito, 49
house fly, 49
northern house mosquito, 49
yellow-fever mosquito, 49
F. W. 293, for control of mites on apple, 329

G-22870 for control of apple aphid, 697
Galgupha quadrisignata, 37
Gamma radiation, use of for control of screw-worm, 467
Garlic injured by *Aceria tulipae*, 612
Geraeus
perscitus, 39
podagrosus, 39
pugnex, 39
senilis, 39
tonsilis, 39
Glycophagus
domesticus, 613
destructor, 754
Glyphonyx
bimarginatus, 192
propinquus, 38
recticollis, 11
Glypta
rufofasciata, 450
simplicipes, 450
Gnathotrichus materiarius, 164
Goniocotes gallinae, 142
Graphocephala coccinea, 3
Grapholitha molesta, 333, 390, 730
Graphomya maculata, 650
Grasshoppers, ecological approach to management of populations, 451
Gymnetis cineria, 38
Gyponana hasta, 749
Gypsy moth, outbreak of in Michigan, 170

Habrocytus medicaginis, 450
Haemaphysalis leporis-palustris, 400
Haematopinus eurysternus, 566
Halisidota caryae, 155
Harrisina brillians, 675
Heleidae, 663
Helina spp., 650
Heliothis
armigera, 39, 110, 293, 416, 422, 518, 568, 600, 619, 629, 712, 714, 740, 744
gelotopoeon, 602
punctigera, 712
virescens, 740
zea, 602
Heliothis armigera
change of name, 600
control of, 198, 199, 225, 442
response of moths to radiation, 175
Heliothrips haemorrhoidalis, 350
Helix aspersa, insecticides against, 698
Helminthosporium
maydis, 443
tercicum, 443
Hemiberlesia
cyanophylli, 615
lataniae, 615
palmae, 615
rapax, 615
sp., 615
Hemicrepidius sp., 193
Hemirhipus fascicularis, 193
Heptachlor, effect of
seed-treatment on corn, 553
seed-treatment on soybeans, 539
soil treatments on strawberries, 700
Heptachlor, for control of
alfalfa plant bug, 720
alfalfa weevil, 288
army cutworm, 227
bean weevil, 757
black vine weevil, 208
black flies, 277
boll weevil, 95
cabbage maggot, 470
chicken lice, 142
chinch bug, 243
clover root curculio, 186
corn earworm, 225, 716
corn flea beetle, 559
Douglas-fir beetle, 503
Egyptian alfalfa weevil, 300
European brown snail, 698
European chafer, 384
garden centipede, 247
grasshopper nymphs, 721
mountain pine beetle, 502
onion thrips, 310
pea leaf miner, 580
pink bollworm, 95
plum curculio, 734
potato leafhopper, 720
soil insects of corn, 255
strawberry root weevil, 208
sweetpotato weevil, 487
tarnished plant bug, 720
white grubs, 648
wireworms, 12
Heptachlor, in HFA No. 1 oil, for control of

boll weevil, 423
bollworm, 423
Heptachlor
reaction of wireworms to, 438
tests with, against house flies, 414
Heptachlor, toxicity of to
chinch bug, 241
German cockroach, 572, 577
house fly, 610, 732
Pseudocneorhinus bifasciatus, 628
squash bug, 250
sweetpotato weevil, 616
Hermetia illucens, 620
Herse cingulata, 487
HETP for control of hop aphid, 707
Hexamethylphosphoramide, systemic effect of, in rabbits, on
bed bug, 140
lone star tick, 140
Hibernation, mortality of boll weevil, 772
Hippodamia convergens, 614
Hirsutella
besseyi, 435
thompsonii, 436
Holcomb-Compound 326, for control of apple aphid, 696
European brown snail, 699
grape mealybug, 102
Homalodisca
centrolineata, 37
insolita, 771
triqueta, 615
Horismenus floridanus, 41, 42
Horistonotus
rufiventris, 38
uhlerii, 38
Horogenes punctorius, 91, 684
Hortensia sp., 615
House flies
control of on military reservations, 528
oxygen consumption of, 627
poison baits for control of, 563
relative toxicity of six insecticides to, 610
Humidity, relative, effects of on lone star tick, 338
Hyalopterus arundinis, 87
Hydrobaenidae, 663
Hydrotaea sp., 650
Hylastinus obscurus, control of, 190
Hylemya
antiqua, 334
brassicae, 249, 470
ciliicrura, 538, 688
floralis, 470
Hylobius spp., 164
Hylotrupes bajulus, 753
Hylurgops pinifex, 164
Hypera
brunneipennis, 297
nigrirostris, 283
postica, 283, 300
Hyperaspis sp , 55
Hyperecteina, 713
Hyphantria cunea, 155
Hypoderma
bovis, 201, 603, 604, 761
lineatum, 201, 603, 604, 761
spp., 461

Icerya purchasi, 447
Ichthyura inclusa, 188
Idona spp., 615
Inbreeding of house flies, 301
Insecticides
absorbed by plants, tests to control insects, 189
analytical methods for determining minimal quantities, 424
band placement of, for control of clover root borer, 190
bioassay to evaluate residues, 210
common names of, 112, 345
comparison of, as larvicides against house flies, 269
control of lice on chickens, 141
device for sub-slab pressure injection of, 479
differential susceptibility of sexes and stages of America cockroach, 131
effect of ingredients on Japanese beetle, 703
effect of soil treatments on strawberries, 700
for larval control of black flies, 274
in mineral oil against corn insects, 714
organic thiophosphate, for fly control on farms, 317
protective devices against 457
reduction of residues on tomatoes, 744
residues of, on vegetables, 590
resistance of lygus bugs to DDT, 509
systemics against black locust insects, 760
systemic, carrier for treating wheat seed, 486
used in automatic cattle sprayers, 386
Insecticides, comparative toxicity to
Cyrtophinus mundulus, 205
Peregrinus maidis, 205
Insecticides, effect on
beneficial insects, 477, 614
cholinesterase of cockroach, 265
development in house flies, 219
flavor and quality of food products, 495
per cent of soluble solids of oranges, 216
seed treatment of dent corn, 549
seed treatment of soybeans, 538
sorghum insects and head sterility, 569
Insecticide-impregnated selfing bags, effect on sorghum insects and head sterility, 571
Insecticides, systemic effect of, in rabbits, on
bed bug, 139
lone star tick, 139
Insect collector, mechanical, 478
Insects
affecting alfalfa seed production, 339
alfalfa, in Wisconsin, 718
beneficial, mortality from insecticides, 477, 614
biology of, peach catfacing, 473
control by internal medication of plants, 187
control in farm-stored grain, 766
control of catfacing, 635
control through use of sexually sterile males, 459
effect of irrigation on damage by, 324
homopterous, on avocado in Central America and Mexico, 614
injurious to birdsfoot trefoil, 447
methods for extracting from flowers, 767
need for common sense in control of, 279
on corn and teosinte in Guatemala, 36
populations, ecological approach to management of, 451
response to black light, 619
soil, control of on corn, 255
techniques for sampling aquatic, 662
Ips
confusus, 478
interpunctus, 501
pini, 164
Ischiodontus fuscus, 193
Isochlorthion, for control of flies on farms, 318
Isodrin, for control of
alfalfa plant bug, 722
bean weevil, 757
corn earworm, 717
European brown snail, 698
garden centipede, 247
grasshopper nymphs, 722
pea leaf miner, 581
plum curculio, 734
potato leafhopper, 722
tarnished plant bug, 722
Isodrin, toxicity of to
German cockroach, 577
house flies, 414
Opius oophilus, 75
oriental fruit fly larvae, 75
Pseudocneorhinus bifasciatus, 628
squash bug, 250
Isolan, for control of
apple aphid, 696
European brown snail, 698
strawberry aphid, 582
Isomers of Systox, chemical behavior of, in biological systems, 347
Iso-octyl thioglycolate, systemic effect of, in rabbits, on
bed bug, 140
lone star tick, 140
Itoplectis conquisitor, 53, 450, 622
Ixodes
attacking man, 327
cookei, 396
scapularis, 396, 400
Ixodid ticks
disease agents recovered from, 396
distribution in Jackson Co., Miss., 400

Karathane, for control of European red mite, 104
Keonolla
confluens, 588, 749
dolobrata, 37

Laemophloeus pusillus, 26
Laphygma frugiperda, 39, 175, 715, 740, 744
Largus (=*Euryophthalmus*), 711
cintus, 37
Lasius niger alienus americanus, 256
Lauseto neu, toxicity of to body lice eggs, 765
Lead arsenate, for control of
cherry fruit fly, 575
codling moth, 598
oriental fruit moth, 391
plum curculio, 735
sugarcane termites, 534
sweetpotato weevil, 644
Lecaniine scale insects, natural enemies of, 53
Lecanium
corni, 53
fletcherii, 279
kunoensis, 53
pruinosum, 53, 508, 769
Lepidosaphes
beckii, 432
gloverii, 445
Leptocera
exiquella, 620
fontinalis, 620
Leptodictya tabida, 37
Leptoglossus zonatus, 37

Leptostylus or *Leiopus* spp., 164
Leptotrachelus testaclus puncticollis, 38, 41
Leptura spp., 164
Lethane, for control of biting flies, 387
Leucophaea maderae, 35, 480
Leucopis puncticornis, 530
Leucotabanus annulatus, 609
Levuana iridescens, 714
Light
  black, response of insects to, 619
  ultra violet, response of insects to, 155
Lime sulfur, for control of
  European red mite, 104
  spotted alfalfa aphid, 674
  strawberry aphid, 582
Limonius canus, 61
Lindane
  differential susceptibility of American cockroach, 131
Lindane, reactions of wireworms to, 438
Lindane, effect of
  soil treatments on strawberries, 700
  treating seed corn with, 550
  treating soybeans with, 539
Lindane, effect of soil-treated black locust on
  Daphnia pulex, 761
  Enchenopa binotata, 761
Lindane, for control of
  alfalfa plant bug, 720
  ambrosia beetles, 164
  apple aphid, 696
  armyworm, 261
  bark beetles, 164
  chicken body louse, 567
  chicken lice, 142
  chinch bug, 243
  clover root curculio, 185
  corn earworm, 225, 716
  corn flea beetle, 559
  corn leafhopper in Hawaii, 205
  Cyrtophinus mundulus, 206
  deer flies, 127
  Douglas-fir beetle, 503
  flies in dairy barns, 307
  garden centipede, 247
  grasshopper nymphs, 721
  green June beetle, 621
  green peach aphid, 56
  horse flies, 127
  Mountain pine beetle, 502
  onion thrips, 311
  pea leaf miner, 581
  potato leafhopper, 720
  roundheaded borers, 164
  seed-corn maggot, 688
  serpentine leaf miner, 596
  silverfish, 221
  soil insects of corn, 255
  strawberry aphid, 582
  sweetpotato weevil, 487
  tarnished plant bug, 720
  weevils, 164
  wireworms, 12
Lindane, technique for bioassay of, 659
Lindane, toxicity of to
  body lice eggs, 765
  chinch bug, 241
  German cockroaches, 572
  house fly, 111, 732
  Opius oophilus, 75
  oriental fruit fly larvae, 75, 313
  Pseudocneorhinus bifasciatus, 628
  squash bug, 250
  sweetpotato weevil, 616
Linognathus vituli, 566
Liriomyza
  langei, 579
  pusilla, 744
  subpusilla, 110, 596
Lissorhoptrus simplex, 665
Locust, desert, cooperative control of, 392
Loxostege similalis, 175, 224
Lucilia
  illustris, 649
  sericata, 461
Lustrochernes reimoseri, 41
Lyctus planicollis, 770
Lygus
  elisus, 148
  hesperus, 148, 509
  lineolaris, 156, 339, 449, 473, 625, 635, 718
  spp., 543
Lygus bug injury to lima beans, 148
Lydella stabulans grisescens, 91, 683, 765

Macrocentrus gifuensis, 91, 684
Macropsis
  insignis, 3
  trimaculata, 3
Macrosiphum
  dirhodum, 87
  granarium, 87
  pisi, 180, 193, 298, 449, 625, 672
  solanifolii, 188, 624, 685, 750
Macrosteles fascifrons, 449, 750
"Maculatum disease," from ticks in Mississippi, 397
Malacasoma americanum, 156, 188
Malathion, effect of diluents on, 762
Malathion effect of on
  grape leafhopper eggs, 220
  seed-treated soybeans, 539
Malathion, for control of
  alfalfa plant bug, 722
  American cockroach, 753
  apple aphid, 696
  blow fly infestations, 182, 565
  brown wheat mite, 157
  cherry fruit fly, 575
  chicken body louse, 567
  Egyptian alfalfa weevil, 293
  European brown snail, 698
  European red mite, 104
  flies in dairy barns, 307
  flower thrips, 769
  garden centipede, 247
  German cockroach, 753
  goat lice, 567
  grasshopper nymphs, 722
  green June beetle, 621
  green peach aphid, 56
  hop aphid, 709
  house fly, 342, 565, 642
  lesser peach tree borer, 736
  mites on apple, 329
  northern fowl mite, 605
  onion thrips, 310
  oriental cockroach, 753
  Phaenicia sericata larvae, 342
  plum curculio, 735
  Polistes exclamans, 162
  short-nosed cattle louse, 566
  potato aphid, 686
  potato leafhopper, 722
  spotted alfalfa aphid, 672
  squash bug, 613
  strawberry aphid, 582
  tarnished plant bug, 722
  two-spotted spider mite, 178, 583
  walnut aphid, 505
Malathion
  ineffective against cyclamen mite, 583
  in traps against oriental fruit fly, 313
  phytotoxicity of to poinsettias, 326
  residual effect with chlorinated terphenyls, 483
  residues on tomatoes, 744
  residues on vegetables, 590
Malathion, systemic effect of, in rabbits, on
  bed bugs, 140
  lone star tick, 140
Malathion, toxicity of to
  chinch bug, 241
  house fly, 111, 680, 732
  Pseudocneorhinus bifasciatus, 628
  sweetpotato weevil, 616
  two-spotted spider mite, 85
Medication of plants, internal, for insect control, 187
Megachile
  brevis, 545
  frigida, 545
  inermis, 545
  latimanus, 545
  melanophaea, 545
  relativa, 545
  texana, 546
Megacyllene robiniae, 760
Megapenthes
  insignis, 193
  rufilabris, 193
Melanoplus
  bivittatus, 449
  femur-rubrum, 449, 718
  mexicanus mexicanus, 119, 718
Melanotus
  communis, 11, 555
  divarcarinus, 193
  parallelus, 193
  secretus, 193
  sp., 256, 438
Melaphagus ovinus
  control of, 195
  longevity and emergence of, 629
Melissopus latiferreanus, outbreak, 340
Membracis mexicana, 615
Menopon gallinae, 142
Mercuric chloride for control of sugarcane termites, 534
Meromyza americana, oviposition preference of, 426
Metacide
  effect of on seed-treated soybeans, 539
  ineffective against cyclamen mite, 583
Metacide, for control of
  brown wheat mite, 157
  Egyptian alfalfa weevil, 299
  green peach aphid, 56
  pea leaf miner, 580
  potato aphid, 687
  strawberry aphid, 582
Metaldehyde for control of European brown snail, 699
Metaphycus
  flavus, 55
  hemilecanii, 55
  praevidens, 55
  spp., 55
Meta-Systox, for control of
  apple aphid, 697
  hop aphid, 709
  spotted alfalfa aphid, 673
Meta-Systox for treating wheat seed, 486
Metatetranychus
  citri, 72, 215, 373, 377, 432
  ulmi, 23, 103, 749, 769
Metator pardalinus, 328
Metcalfiella monogramma, 615
Methods (see also technique)

adaptation of dosage-mortality curves to machine calculation, 335
analytical, with respect to determining minimal quantities of insecticides, 424
applying dieldrin against European chafer, 385
applying insecticides against rutabaga maggots, 470
artificial insemination of queen bees, 418
bioassay for evaluation of insecticide residues, 210
chemical assay of chlorobenzilate residues, 373
control of meadow spittlebug by pre-emergence treatment, 593
control of oriental fruit fly, 311
control of silverfish with lindane in liquid floor wax, 221
Daphnia to help screen systemics, 759
determining penetration of foliage canopy by aerial spray, 629
emergency measures against Mexican fruit fly, 657
eradication of screw-worm from Curacao, 463
extracting insects from rose flowers, 767
fogging dairy barns for fly control, 330
for determining excretion of radioactive metabolite by house flies, 736
inbreeding house flies, 301
laboratory bioassay, to determine distribution of chemicals in the soil, 61
measuring effectiveness of natural enemies of Diaspine scale insects, 584
measuring wireworm reactions to soil insecticides, 438
mixing dusts in laboratory, 218
predicting hatching date of meadow spittlebug, 204
repellents against mosquitoes, 68
speedlight calibration in photography, 82
spraying barrier-strips to control rice field mosquitoes, 107
tagging wireworms with cobalt-60, 438
testing respirator devices, 457
treating seed corn with insecticides, 549
treating sorghum selfing bags, 568
treating soybean seed, 538

Methods for rearing
citrus red mites, 72
corn flea beetle, 556
Garman spider mite, 47
honey bee larvae *in vitro*, 43
large cockroaches, 480
stable flies in laboratory, 327

Methoxychlor
as a larvacide against house flies, 270
differential susceptibility of American cockroach, 131
effect of low dosages on California red scale, 586

Methoxychlor, for control of
alfalfa plant bug, 720
armyworm, 261
bean weevil, 757
biting flies, 387
black vine weevil, 208
chicken body louse, 567
codling moth, 598
corn earworm, 716
corn flea beetle, 559
Egyptian alfalfa weevil, 299
European brown snail, 698
flies in dairy barns, 307
grasshopper nymphs, 721
meadow spittlebug, 594
potato leafhopper, 720
strawberry root weevil, 208
tarnished plant bug, 720
tomato fruitworm, 519

Methoxychlor
toxicity of to house fly strains, 610
Pseudocneorhinus bifasciatus, 628

Methyl bromide, effective against apple maggot, 484

Methyl bromide, effect of fumigation with on avocado fruits, 369

Methyl-Chlorobenzilate not harmful to aphids and leafhoppers, 750

Methyl ethyl ketone, 153

Methyl eugenol, attrahent for, oriental fruit fly, 311

Methyl parathion, for control of
apple aphid, 696
boll weevil, 95
brown wheat mite, 160
Egyptian alfalfa weevil, 299
grape mealy bug, 102
onion thrips, 310
pea leaf miner, 580
pink bollworm, 95
plum curculio, 735

Methyl parathion, toxicity of to sweet-potato weevil, 616

Microgaster comptanae, 622

Microtermes obesi, 533

Microweisea
coccidivora, 435
sp., 445
Mindarus abietinus, 87

Mites injurious to stored grain, 754

Mitox
for control of European red mite, 105
not harmful to leafhoppers, 750

Mixer, laboratory dust, 217

Moisture, effect of, on emergence of southern lyctus beetle, 770

Monelepta sp., 39

Monochamus sp., 164

Mosquitoes, control of, 330

Musca
domestica, 49, 146, 153, 182, 306, 317, 330, 342, 354, 403, 407, 413, 430, 482, 488, 528, 563, 610, 620, 623, 627, 642, 650, 680, 731, 736, 747
vicina, 638

Musca domestica
attacked by ants, 28
effect of a sulfone in pyrethrum and allethrin sprays, 9
fecundity and cold survival of, 654
inbreeding of, 301
indirect effects of chemicals on, 219
inhibited by piperonyl butoxide, 93
toxicity of insecticides to larvae, 109
toxicity of insecticides to two strains, 111

Muscidae, 649

Muscina
assimilis, 650
stabulans, 620

Mydaea spp., 650

Myiophagus sp., 433

Mylar, 109

Myospila meditabunda, 650

Myzocallis
robiniae, 87
trifolii, 614

Myzus persicae, 56, 188, 333, 624, 629, 750, 751

Nabam, for control of European brown snail, 699

Nauphoeta cinerea, oötheca of, 35

Nectar flows, in Manitoba, 514

Nemobius fasciatus fasciatus, 449

Nemocestes incomptus, 208

Neocenchrae gregaria, 38

Neodiprion lecontei, 188

Neorhynchocephalus sackenii, 328

Nicotine, for control of
apple aphid, 696
flower thrips, 769
green peach aphid, 56
spotted alfalfa aphid, 672
strawberry aphid, 582
walnut aphid, 505

Noctua c-nigrum, 155

Nosema disease, 724

NPD, effect of on seed-treated soybeans, 539

NPD, for control of
apple aphid, 696
brown wheat mite, 157
Egyptian alfalfa weevil, 293
pea leaf miner, 580
potato aphid, 687
short-nosed cattle louse, 567
spinach leaf miner, 581
strawberry aphid, 582

Obituary
Charles Harold Alden, 778
Samuel Bradford Doten, 632
Charles Lester Marlatt, 228
Austin Winfield Morrill, 230
Lawrence Peck Rockwood, 631
William Jay Schoene, 632
George Haymaker Vansell, 231
Ernest Ralph Sasscer, 777

Odontotermes assmuthi, 533

Oil, isoparaffinic, solutions of insecticides in, against cotton insects, 422

Oil sprays, effect of on soluble solids of oranges, 216

Olla abdominalis var. *plagiata*, 436

Ommatopteryx ocellea, 619

Onchocerciasis, vectors of human, 378

Oncometopia
obtusifrons, 37
sp., 615

Oncopeltus fasciatus, 730

Onypterygia famini, 38, 39

Oöthecae, cockroach, 33

Ophyra spp., 182

Opius
dimidiatus, 597
longicaudatus, 75
oophilus, 75, 316
vandenboschi, 75

Orius insidiosus, 768

Orthezia acapulcoa, 38

Orthodichlorobenzene, for control of
Ips interpunctus, 502
mountain pine beetle, 502
Pityogenes carinulatus, 502

Ortho HL-609, effect of on seed-treated soybeans, 539

Orthostethus infuscatus, 193

Orthotomicus caelatus, 164

Oryzaephilus surinamensis, 26, 109

Oscinella
magnicornis, 41
nigronotata, 41

OS-1808, for control of corn earworm in sorghum heads, 225

OS-2406, for control of
corn earworm in sorghum heads, 225
mosquitoes in rice fields, 556

Otoscope, use of in entomology, 755
Oviposition preference of *Meromyza americana* affected by,
color of light reflected from the plants, 428
growth stage of seedlings, 428
Ovotran, for control of
brown wheat mite, 157
citrus red mite, 375
European red mite, 103
garden centipede, 247
mites on apple, 329
strawberry aphid, 582
two-spotted spider mite, 178
Yuma mite, 375
Pachyta spp., 164
Packaging films for stored-product insects, 108
Padaeus
irroratus, 37
trivittatus, 37
Pangaeus sallei, 37
Papaipema nebris, 765
Paradexodes epilachnae, 758
Paraleyrodes sp., 614
Parallelostethus attenuatus, 193
Parasites of
European corn borer in Conn., 91
Lecaniine scale insects, 53
red-banded leafroller, 53
Paratheresia claripalpus, 41
Parathion, absorbed by plants, tests of toxicity to
eastern tent caterpillar, 189
Mexican bean beetle, 189
two-spotted spider mite, 189
Parathion, action of to eggs of
large milkweed bug, 730
lesser peach tree borer, 730
oriental fruit moth, 730
peach tree borer, 727
plum curculio, 730
Parathion, effect of on
oriental fruit moth, 390
serpentine leaf miner, 596
soluble solids of oranges, 216
Parathion, for control of
alfalfa plant bug, 720
apple aphid, 696
armyworm, 261
boll weevil, 95
brown wheat mite, 157
cherry fruit fly, 575
chinch bug, 243
codling moth, 305, 598
corn earworm, 443
corn flea beetle, 559
corn leafhopper in Hawaii, 205
Cyrtophinus mundulus, 206
Egyptian alfalfa weevil, 299
European brown snail, 698
European red mite, 103
flower thrips, 769
garden centipede, 247
grasshopper nymphs, 721
green June beetle, 621
green peach aphid, 56
grape mealybug, 101, 607
hop aphid, 707
lesser peach tree borer, 736
mosquitoes in rice fields, 665
onion thrips, 310
peach catfacing insects, 635
peach tree borer, 736
pea leaf miner, 580
plum curculio, 734
potato aphid, 686
potato leafhopper, 720
short-nosed cattle louse, 566
spinach leaf miner, 581
spotted alfalfa aphid, 672
squash bug, 254, 613
strawberry aphid, 581
sugarcane termites, 536
tarnished plant bug, 720
tomato fruitworm, 519
two-spotted spider mite, 583, 707
walnut aphid, 505
wireworms, 12
Parathion
ineffective against cyclamen mite, 583
in oil, for control of corn earworm, 225
in traps vs. oriental fruit fly, 311
per cent recovered from samples, 218
protective devices against, 457
residual effect with chlorinated terphenyls, 483
residues of on vegetables, 590
residues on tomatoes, 744
Parathion, toxicity of to
chinch bug, 241
cotton insects, 294
citrus red mite, 215
house flies, 680, 732
Opius oophilus, 75
oriental fruit fly larvae, 75
Pseudocneorhinus bifasciatus, 628
squash bug, 250
two-spotted spider mite, 215
Parasetigera silvestris, 711
Paratrechina longicornis, 28
Paregle spp., 650
Parlatoria pergandii, 445
Particle size in DDT dust, effect of, on control of corn earworm, 416
Pectinophora gossypiella, 95, 174, 293, 626, 677, 740, 767
Pediculus humanus humanus, 764
Pegomya
hyoscyami, 579
spp., 650
Pelopiinae, 663
Pentachlorophenyl acetate, toxicity of to citrus red mite, 215
two-spotted spider mite, 215
Pentatomidae, 635
Penthion for control of flies, 307, 318
Peregrinus maidis, 37
toxicity of insecticides to, 205
Peridroma margaritosa, 40
Periplaneta americana, 33, 49, 131, 265-480, 482, 747
Periplaneta americana, metabolism of Systox in, 355
Periplaneta, trapped,
americana, 107
brunnea, 107
Perkinsiella saccharicida, 205
Peronea minuta, 223
Perthane, for control of
alfalfa plant bug, 720
bean weevil, 757
corn earworm, 716
corn flea beetle, 559
Egyptian alfalfa weevil, 300
European brown snail, 698
German cockroach, 753
grasshopper nymphs, 721
plum curculio, 735
potato leafhopper, 720
spotted alfalfa aphid, 672
tarnished plant bug, 720
Petrobia latens, control of, 157
Phaenicia
cuprina, 564
sericata, 342
spp., attacked by ants, 28
Pheidole subarmata borinquensis, 28
Phenethyl alcohol, systemic effect of, in rabbits, on
bed bug, 140
lone star tick, 140
Phenethyl butycate, systemic effect of, in rabbits, on
bed bug, 140
lone star tick, 140
Philaenus leucophthalmus, 191, 204, 324, 593, 718
Phormia regina, 235
Phorodon humuli, 706
Phosphorus compounds, tests with, against cattle grus, 201
Photography, speedlight calibration for, 82
Phyllocoptruta oleivora, 377, 432, 444
Phyllophaga, 256, 487
Phytophaga destructor, 608
Phytotoxicity of
acaricides under greenhouse conditions, 749
insecticide seed-treated soybeans, 538
malathion to poinsettias, 326
Pieris rapae, 188
Pimplopterus sp., 622
Pinhole injury by pea weevil, factors affecting, 693
Piperonyl butoxide
inhibition of development of house fly, 93
in house fly sprays, 407
Piperonyl butoxide-pyrethrins, for control of
cadelle, 26
corn earworm, 200
flat grain beetle, 26
lesser grain borer, 26
rice weevil, 25
saw-toothed grain beetle, 26
Pirazinon, for control of
flies in dairy barns, 308
flies on farms, 318
oriental fruit fly, 313
short-nosed cattle louse, 566
Pirazinon, toxicity of to house flies, 680
Pissodes approximatus, 164
Pityogenes
carinulatus, 502
hopkinsi, 164
2-Pivalyl indandione for control of short-nosed cattle louse, 566
Plathypena scabra, 450
Platymetopius magdalensis, 1
Pleurotropis epilachnae, 758
Plodia interpunctella, 109
Pococera atramentalis, 41
Podisus
maculaventris, 473
sagitta, 37
Polistes exclamans, biology and control of, 161
Pollen, alfalfa, on nectar-collecting honey bees, 477
Polypropylene glycol (Cray Fly Repellent) with Diazinon against house flies, 488
Popillia japonica, 703, 713
Porthetria dispar, 170, 263
Potasan, for control of
European brown snail, 698
green June beetle, 621
potato aphid, 686
Praon spp., 670
Predators, coccinellid, of Lecaniine scale insects, 55

Procladius bellus, 663
Prodenia
eridania, 487
ornithogalli, 740
Prolan, for control of
alfalfa plant bug, 722
corn earworm, 716
European brown snail, 698
grasshopper nymphs, 722
potato leafhopper, 722
tarnished plant bug, 722
Prospaltella
aurantii, 435, 444
clypealis, 682
elongata, 446
opulenta, 682
pericosi, 445
smithi, 682, 711
spp., 444
Protoparce, response to lights,
quinquemaculata, 177, 740
sexta, 177, 526, 740
Protophormia terra-novae, 649
Psallus seriatus, 177, 293
Pseudaletia unipuncta, 156, 256, 740
Pseudaphycus mundus, 711
Pseudhomalopoda prima, 435
Pseudococcus
boninsis, 711
maritimus, 101, 607
Pseudocneorhinus bifasciatus, 628
Pseudomops intercepta, 37
Psorophora
confinnis, 30, 108, 665, 741
discolor, 30, 108, 665
Pterocalla costalis, 41
Pycnoscelus surinamensis, 35
Pyrausta nubilalis, 91, 200, 606, 611, 683, 765
Pyrazoxon, control of onion thrips, 311
Pyrellia cyanicolor, 650
Pyrenone for control of bean weevil, 757
Pyrethrins, effectiveness against,
biting flies, 387
common malarial mosquito, 51
house flies, 50, 407, 413
northern house mosquito, 51
yellow-fever mosquito, 51
Pyrethrins
synergized, for control of cattle grubs, 603
Pyrethrins, toxicity of to
American cockroach, 747
German cockroach, 747
house fly, 680, 747
Pyrethrum, control of corn earworm, 715
Pyrolan, for control of
European brown snail, 699
oriental fruit fly, 313
strawberry aphid, 582
Pytho americanus, 164

Quassia (Picrasmin), tests of toxicity to
cabbage aphids, 188
cowpea aphid, 188
eastern tent caterpillar, 188
green peach aphid, 188
imported cabbageworm, 188
Mexican bean beetle, 188
needle-feeding woolly aphid, 188
poplar tent maker caterpillars, 188
potato aphid, 188
redheaded pine sawfly 188
two-spotted spider mite, 188

R-242, for control of brown wheat mite, 157
Radiation, atomic, for insect control, 459
Radioactive material, use of
carbon^{14}-labeled DDT, 736
cobalt-60, 438, 467
phosphorus-32, 19, 31, 79
phosphoric acid, 616
P^{32}-labeled technical Systox, 364
Raphignathus sp., 447
Relation of water loss to egg hatching,
Blattella germanica, 57
Blattella vaga, 59
Repellents
against mosquitoes, 67, 741
insecticides to Japanese beetle, 703
tick, 499
Repellents, tests
against American dog tick, 772
against horn flies and stable flies with oil base sprays, 410
fly sprays against *Tabanus sulcifrons*, 167
with water emulsion sprays, 411
Residues of
aldrin improved for insect control, 153
chlorobenzilate in lemon fruits, 372
DDT improved for insect control, 153
DDT in fat of steers pastured in treated fields, 606
demeton and parathion against tulip bulb aphid, 108
demeton in peas following treatment for aphids, 195
demeton on field-grown peas of different maturity, 194
dieldrin in sheep tissues after treatment for ked, 196
insecticide, evaluation of by bioassay, 210
insecticides on strawberries, 700
insecticides on vegetables, 590
lindane improved for insect control, 153
malathion on lettuce, 151
malathion on vegetables, 209
on mature tomatoes, 744
parathion on celery, 88
parathion on immature peaches, 44
schradan in peas treated for pea aphid, 180
Systox, in plant materials, 364
Resistance
American cockroach to Chlorthion, 753
codling moth to DDT, 598
German cockroach to chlordane, 753
green peach aphid to orango-phosphorous, 56
house fly to DDT, 406, 638
ovicides by eggs of body lice, 764
wheat to races of hessian fly, 608
Respiratory protective devices for agricultural use, 457
Reticulitermes flavipes, 753
Rhagoletis
cingulata, 575, 616, 617
completa, 752
faust, 575
pomonella, 484
Rhipicephalus sanguineus, 400
Rhizoglyphus
callae, 613
echinopus, 334
solani on onions, 334
Rhopalosiphum
maidis, 568
prunifoliae, 38, 42
Rhopobota vacciniana, 223
Rhyzopertha dominica, 26,109
Rickettsia
rickettsii, 399
typhi, 396
Rocky Mountain spotted fever, 399
Rodolia cardinalis, 447, 758
Rotenone, for control of
cattle grubs, 604
corn earworm, 198, 715
spotted alfalfa aphid, 673
Rotenone, resistance of Mexican bean beetle to, 343
Rutabagas, root maggot control, 470
Ryanexcel 96-3, codling moth control, 305
Ryania, for control of
corn earworm, 198
corn flea beetle, 559
Ryanicide 100, codling moth control, 305

Saissetia
hemisphaerica, 53
oleae, 53
persimile, 54
spp., 54
Sanninoidea exitiosa, 727, 734
Sarcophaga spp., 30, 182
Scaphoideus luteolus, 3, 279
Scaphytopius
acutus, 339, 588, 749
magdalensis, 1, 106
nigrifrons, 1
sp., 615
verecundus, 1, 106
Schistocerca gregaria, 392, 576
Schradan
content in peas in relation to pea aphid control, 180
effect of on aphid predators, 530
for treating wheat seed, 486
Schradan, effect of soil-treated black locust on
Daphnia pulex, 761
Enchenopa binotata, 761
Schradan, for control of
alfalfa plant bug, 722
brown wheat mite, 157
corn flea beetle, 559
Douglas-fir beetle, 501
frosted scale, 769
garden centipede, 247
grasshopper nymphs, 722
hop aphid, 708
Ips interpunctus, 501
mountain pine beetle, 501
Pacific spider mite, 508, 769
potato leafhopper, 722
strawberry aphid, 582
tarnished plant bug, 722
two-spotted spider mite, 583, 708
walnut aphid, 505, 768
Schradan, systemic effect, in rabbits, on
bed bug, 139
lone star tick, 139
Sciara sp., 256
Scleroracus vaccinii, control of, 222
Scolothrips sexmaculatus, 280, 437
Scopeumatidae, 649
Scutigerella immaculata, control of, 246
Scybalista cinera, 40
Scymnus syriacus, 530
Seed
beetles on corn, 256
maggots on corn, 256
Selenaspidus articulatus, 615
Senopterina cyanea, 41
Shell OS 1808, for control of
blow flies, 564
house flies, 565
Shell OS 2046, for control of
blow flies, 564
house flies, 565

Simulium
callidum, 274, 378
metallicum, 274, 378
neavei, 379
ochraceum, 274, 378
spp., 202
Siphona irritans, 386, 410
Sitona hispidula, biology and control, 184
Sitophilus
granarius, 109
oryzae, 25, 39, 109, 774
Sodium arsenite, for control of grape mealybug, 102
Sofus pilicornis, 42
Soil insects of corn, 255
Solenopsis
corticalis, 28
geminata, 28, 38, 42, 446
Soybeans, seed treatments, 538
Sparganothis sulfurana, 223, 450
Sphaerophoria flavicauda, 530
Spilochalcis flavopicta, 622
Spray, aerial, penetration of foliage canopy of corn and potatoes, 629
Sprayers, treadle, performance of, 167
Stegobium paniceum, 109
Stenocerus lineatus, 164
Sterilization, vapor heat, against fruit fly insects, 133
Stethorus utilis, 436
Stictolobus minor, 615
Stictopelta indeterminata, 615
Stomoxys
calcitrans, 147, 317, 327, 330, 386, 410
sp., 309
Stored grain
insect control in, 766
insects, effect of streptomycin on, 774
Streptomycin, effect of on stored-grain insects, 774
Strobane, for control of
apple aphid, 697
chicken body louse, 567
European brown snail, 698
German cockroach, 753
goat lice, 567
lone star tick, 224
mites on apple, 329
plum curculio, 735
short-nosed cattle louse, 566
Sulphenone, for control of
European red mite, 103
garden centipede, 247
strawberry aphids, 582
Sulfone, in pyrethrum and allethrin mixtures against house fly, 9
Sulfotepp, for control of
grape mealybug, 102
strawberry aphid, 582
Sulfoxide in house fly sprays, 407
Sulfur, for control of strawberry aphid, 582
Supella supellectilium, 35
Surveys,
citrus blackfly, 414
faunistic, relation of to applied entomology, 776
Syanthedon pictipes, 734
Sylvilagus floridanus alacer, 400
Sympherobius sp., 607
Sympiesis
sp., 622
viridula, 765
Synanthedon pictipes, 730
Synergism, Dilan plus pyrethrum synergists against
house flies, DDT-resistant, 146
stable fly, 147
Synergists
action of, for DDT against house flies, 403
for DDT, diaryl-trifluoromethyl-carbinols, 638
of furethrin, 49
Syrphid larvae, 670
Systox (see also demeton)
effect of on aphid predators, 530
metabolism of, in American cockroach and white mouse, 355
residues, nature and significance of in plant materials, 364
Systox, for control of
alfalfa plant bug, 720
blunt-nosed cranberry leafhopper, 222
cranberry scale, 223
Douglas-fir beetle, 501
frosted scale, 508
garden centipede, 247
grasshopper nymphs, 721
green peach aphid, 56
Ips interpunctus, 501
mites on apple, 329
mountain pine beetle, 501
Pacific spider mite, 508
potato aphid, 686
potato leafhopper, 720
spotted alfalfa aphid, 672
tarnished plant bug, 720
walnut aphid, 505, 769
wireworms, 17
Systox isomers
chemical behavior of in biological systems, 347
systemic activity of derivatives of, in the cotton plant, 353
Systox isomer derivatives, toxicity of to
house fly, 354
mites, 354
thrips, 354
white mouse, 354

Tabanidae,
control of, 330
Oklahoma list, 763
Tabanus
abactor, 618
americanus, 609
astutus, 125
atratus, 609
cymatophorus, 609
equalis, 609, 618
fulvulus, 609
fuscicostatus, 609
hearlei, 125
lineola, 609
metabolus, 125
mularis, 609
proximus, 609
septentrionalis, 125
sp., 125, 386, 410
sulcifrons, 167, 609, 618
turbidus, 609
typhus, 125
zonalis, 125
Tapinoma melanocephalum, 28
Tarsonemus pallidus, 583
Taxonomy, interrelations of with biological control, 710
TDE, effect of on serpentine leaf miner, 596
TDE, for control of
chicken body louse, 567
corn earworm, 716
European brown snail, 698
tomato fruitworm, 519
TDE, residues on tomatoes, 744
Technique (see also Methods)
artificial insemination of queen bees, 418
bioassay of lindane, 659
estimating percentage of honey bees visiting alfalfa, 484
insecticidal treatment of wheat seed with systemic toxicants, 486
sampling aquatic insects, 662
Temperatures, effect of low, on
bacterial wilt of corn, 561
corn flea beetle, 561
Tendipendini, 663
Tenebroides mauritanicus, 26, 109
Teosinte, insects on in Guatemala, 36
TEPP, for control of
apple aphid, 696
brown wheat mite, 157
flower thrips, 769
green peach aphid, 56
hop aphid, 707
house fly larvae, 342
pea leaf miner, 581
potato aphid, 687
spotted alfalfa aphid, 673
strawberry aphid, 582
TEPP, protective devices against, 457
TEPP, toxicity of to
house fly, two strains, 111
insect vectors, 749
two-spotted spider mite, 85
Termites, sugarcane, control of, 533
Terphenyl, chlorinated, 153
residual effectiveness of insecticides with, 482
Tetralicia sp., 614
Tetranychus
bimaculatus, 23, 85, 177, 188, 215, 221, 279
bimaculatus mullisetus, 42
pacificus, 769
schoenei, 329
telarius, 329, 350, 582, 707, 749, 762
tumidus, 293
Tetrastichus bruchophagi, 450
Tettigella
instrata, 615
miniaticeps, 615
Tettigellinae, 771
Thanite
for control of biting flies, 387
Polistes exclamans, 162
Tabanus sulcifrons, 167
Therioaphis
maculata, 668, 671
trifolii, 671
Thiram seed treatments, 688
Thrips, damage to hairy vetch, 626
Thrips tabaci, control of, 310
Thyanta custator, 473
Thysanura, control of, 221
Thysanus fasciatus, 446
Tiphia vernalis, 714
TIPP for control of strawberry aphid, 582
Tobacco hornworm, mating habits of, 526
Tomaspis postica, 615
Tortrix
pallorana, 450
velutinana, 450
Troymus druparum, 620
Toumeyella sp., 615
Toxaphene
as a larvacide against house flies, 271
differential susceptibility of American cockroach, 131
residues of on vegetables, 590
Toxaphene, effect on
beneficial insects, 477

boll weevil, 605
California red scale, 586
seed-treated soybeans, 541
serpentine leaf miner, 596
Toxaphene, for control of
alfalfa plant bug, 720
alfalfa weevil, 287
army cutworm, 227
armyworm, 261
bean weevil, 757
black vine weevil, 208
brown wheat mite, 159
chicken body louse, 567
chinch bug, 243
clover root curculio, 186
corn earworm, 225, 715
corn flea beetle, 559
Egyptian alfalfa weevil, 298
European brown snail, 698
European chafer, 384
garden centipede, 247
garden webworm, 224
grasshopper nymphs, 721
insects affecting alfalfa seed production, 339
lone star tick, 224
lygus bugs, 511
meadow spittlebug, 594
mountain pine beetle, 502
onion thrips, 310
pea leaf miner, 580
potato leafhopper, 720
short-nosed cattle louse, 566
spotted alfalfa aphid, 672
sugarcane termites, 536
strawberry root weevil, 208
tarnished plant bug, 720
tomato fruitworm, 520
Toxaphene, toxicity of, to
boll weevil, 293
chinch bug, 241
cotton insects, 294
house fly larvae, 732
Pseudocneorhinus bifasciatus, 628
squash bug, 250
sweetpotato weevil, 616
Traps
against Japanese beetle, 705
for pink bollworm, 767
light studies 1954, 740
wind-vane, for aphids, 624
Treatments, effect of alfalfa irrigation on two-spotted spider mite, 221
Trialeurodes
floridensis, 615
similis, 614
Triatoma
gerstaeckeri, 330
recurva, hosts and distribution, 330
Tribolium
castaneum, 774
confusum, 109, 482
Tichlorobenzene for control of peach tree borer, 736
Trichogramma minutum, 41
Trichoplusia ni, response to lights, 175, 740
Trichopoda pennipes, 711
Trichopria sp., 41, 42
Trichopsidea clausa, 328
Trichoptera, 663
Trigonotylus ruficornis, 156
Trioza anceps, 615
Trogoderma
granarium, 332, 773
parabile, 109
Typhlocyba
prunicola, 476
quercus, 476
rosae, 750
Typhlodromus
elimination of, 73
floridanus, 437
peregrinus, 434
spp., 435, 445
Tylozygus
fasciatus, 615
sp., 615
Tyroglyphus farinae, 754
Tyrolichus casei, 754
Tyrophagus
castellanii, 754
longior, 754
noxius, 754

Ultraviolet and visible radiation, response of cotton insects to, 173
Ultra violet lights, response of insects to, 155
Unilachnus parvus, 188

Vapor heat sterilization against fruit fly insects, 133
Vectors, leafhopper, of phony peach, 771
Vorticella microstoma, infesting *Anopheles atroparvus*, 215

Wagneri, sp., 712
Western X-disease virus, transmitted by nymphs of leafhoppers, 588
White mouse
metabolism of Systox in, 355
toxicity of Systox isomer derivatives to, 354
Wireworms
attzcking corn, control of, 11
control of with insecticide-treated corn seed, 555
distribution and abundance in Southeastern States, 191

Xeropholoea viridis, 750
X-rays, effect of on sterility, 467

Zabrotes subfasciatus, 757
Zagrammosoma sp., 597
Zaleptopygus flavo-orbitalis, 683
Zelia vertebrata, 42
Zicca taeniola, 37
Zygoptera, 663

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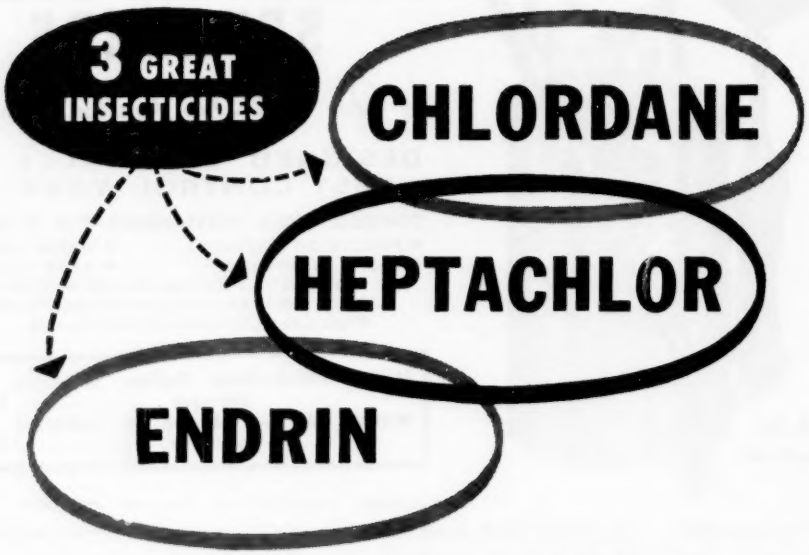

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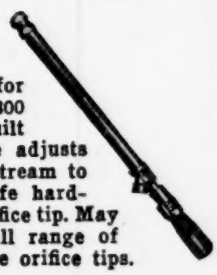

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70% TOXAPHENE · 15% ARAMITE · 75% DDT
50% HEPTACHLOR · 75% DIELDRIN

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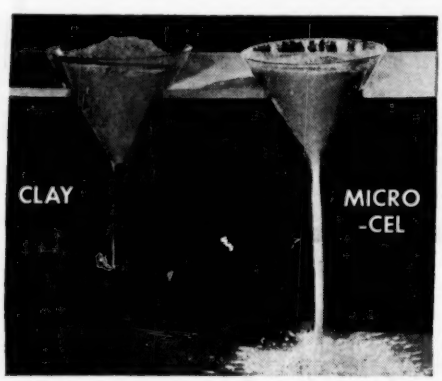

Flows like a liquid—Micro-Cel maintains its exceptional free-flow properties even after absorbing high concentrations of poisons.

Excellent storage properties

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Meets tropical storage test—Suspension values of 1.5 to 2.0 after storage can be achieved in 75% DDT wettable powder formulation when based on Micro-Cel.

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50% HEPTACHLOR

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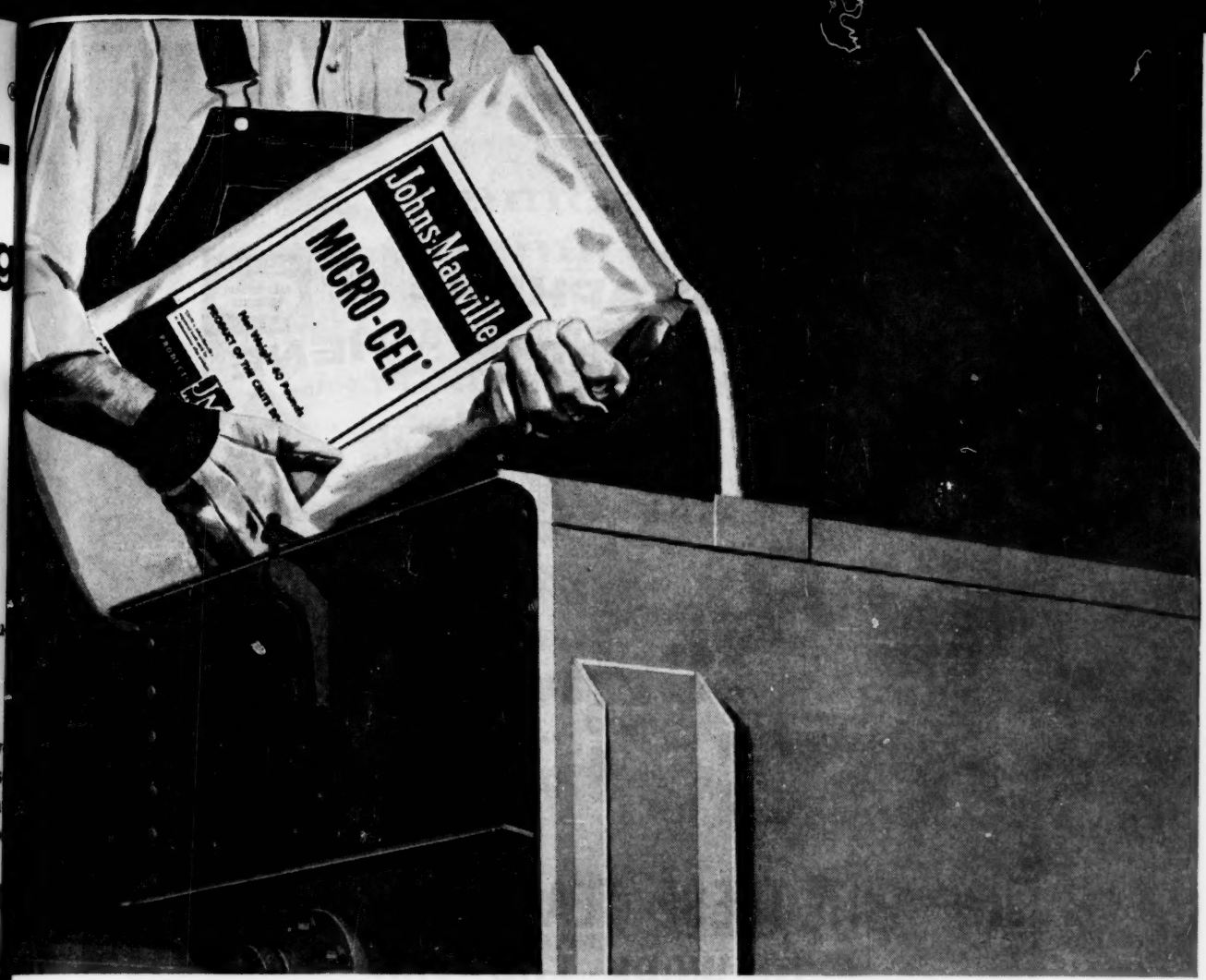

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Micro-Cel is now being produced on a pilot plant basis. Full-scale production is anticipated early in 1956. Sample quantities, as well as limited carload shipments for plant tests, are now available. We will also send you further data and formulations developed and tested in our laboratory for whichever poisons are of interest to you. If you desire, a Celite engineer will be glad to work with you in adapting Micro-Cel to your particular requirements and specifications. Write now in order to be ready with new improved products for the next crop year.

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8B	off-white	225	200	15	150
8C	white	400	425	9	175
8D	off-white	300	350	12	100
8E	off-white	425	475	6	95

Average ultimate particle size is in range of 0.02-0.07 microns
pH—8.0-10.0

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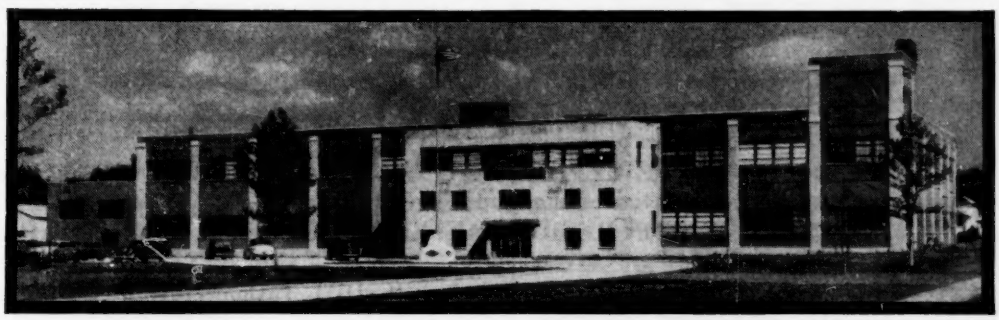

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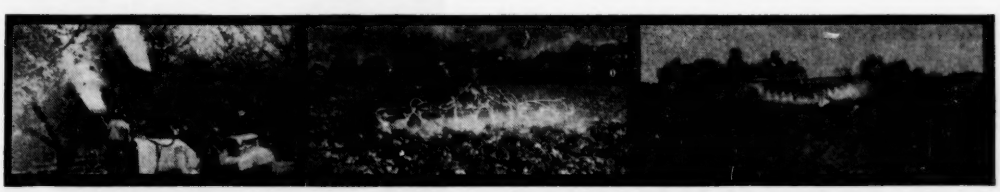
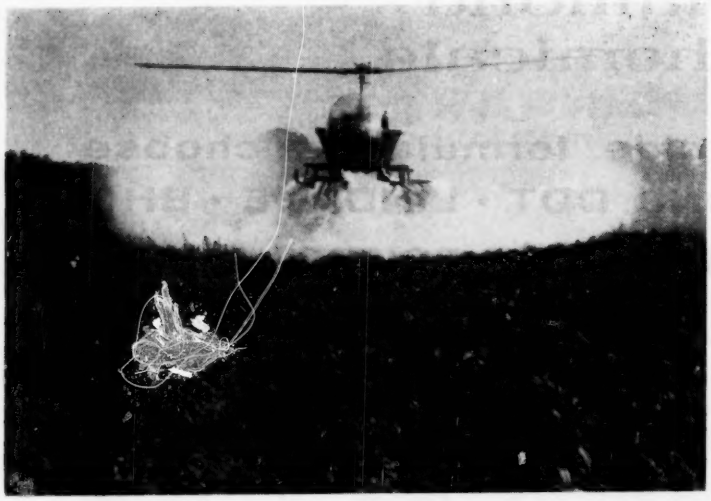


Why Growers Find



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